INTERMOUNTAIN POWER PROJECT
INTERMOUNTAIN GENERATING STATION
UNITS 1 AND 2

SUMMARY TEST REPORT FOR WET SCRUBBER PERFORMANCE TESTS

B&V PROJECT 9255
B&V FILE 74.0202

ISSUE DATE
081088

Black & Veatch
Engineers-Architects

IP12_006690

CONTENTS

CONTENTS (Continued)

CONTENTS (Continued)

LIST OF TABLES AND FIGURE

CONTENTS (Continued)

LIST OF TABLES AND FIGURE (Continued)

INTERMOUNTAIN POWER PROJECT
INTERMOUNTAIN GENERATING STATION
UNITS 1 AND 2

SUMMARY TEST REPORT FOR WET SCRUBBER SYSTEM

1.0 INTRODUCTION

The Intermountain Generating Station (IGS) located near Delta, Utah, consists of two 750 MW pulverized coal fired steam generators, Units 1 and 2, which are designed to burn Utah coal. Each steam generator is equipped with an air quality control system including a fabric filter for particulate emissions control and a wet scrubber for removal of sulfur dioxide from the flue gas.

The Units 1 and 2 wet scrubber systems are equipped with a common limestone preparation subsystem. Additionally, a common sludge conditioning system provides for disposal of combustion waste from both steam generators.

Unit 1 began commercial operation in June 1986; Unit 2 began commercial operation in June 1987. To fulfill the requirements of the procurement contract and to ensure proper operation of equipment, the wet scrubber systems were tested to quantify performance parameters.

This report presents a summary of the performance testing of the Units 1 and 2 wet scrubber systems supplied by General Electric Environmental Services, Inc. Performance tests were conducted on Units 1 and 2 during June and July 1987, respectively. The properties of the coal burned in the steam generators during these tests closely reflected the expected typical coal properties used for design. Also, performance tests were conducted on Unit 1 while a higher sulfur coal was burned. The results of the high-sulfur tests are presented in a separate document.

The Contract 9255.62.0202, for supply of the wet scrubber, guarantees the following items which were monitored during the performance tests.

- Sulfur dioxide emission rate.
- Sulfur dioxide removal efficiency.
- Particulate emission rate.

- Opacity.
- Rated capacity.
- Minimum load operation.
- Pressure loss.
- Stoichiometric ratio.
- Limestone consumption.
- Water consumption.
- Power consumption.

A Wet Scrubber and Sludge Conditioning System Test Plan was developed to coordinate and describe the test plan and test methods for testing the wet scrubbers.[1*] In most cases, specific measurement or calculational procedures associated with the performance tests are addressed in the Test Plan.

For the wet scrubber tests, flue gas testing as well as limestone and slurry solids analyses were performed by Interpoll, Inc. Steam generator and air quality control systems operating data were recorded by Intermountian Power Service Corporation (IPSC) and Black & Veatch (B&V) personnel. Wet Scrubber Performance Test Reports for Units 1 and 2, which contain the flue gas measurement data and solids analyses, were provided by Interpoll, Inc.[2,3] This report presents the overall review of the activities and results of the tests including schedule, unit operating conditions during the tests, test methods, and test results for the Units 1 and 2 wet scrubber systems.

---

*References are listed at the end of the report under Reference Documents.

2.0 SUMMARY

2.1 TEST SCHEDULE

The Intermountain Generating Station wet scrubber system performance tests were conducted June 1 through June 12, 1987 for Unit 1[2] and July 8 through July 12, 1987 for Unit 2.[3] The performance tests were conducted to verify performance guarantees for the Units 1 and 2 wet scrubber systems as listed in the Contract.

Guarantees for the wet scrubber were tested by operation of the steam generator while burning coal with properties within the ranges which are typically expected over the life of the units. This included unit load tests at 100, 75, 50, and 25 (or lowest attainable load) percent of maximum continuous rating (MCR) for verification of overall system guarantees. Unit load tests were held during the week of June 1, 1987 for Unit 1 and July 12, 1987 for Unit 2. Each load desired for testing was obtained approximately 2 hours before the test began. For the purposes of performance testing, the MCR of the steam generator is defined as 840 MW gross and 25 percent of MCR was defined as 210 MW.

In addition, testing was performed to verify the rated capacity tests of the wet scrubber system and modules. Rated capacity of the wet scrubber is the ability of the overall system and the individual modules to conform with applicable guarantees while operating within the intended design capacity of the equipment. The rated capacity tests for the wet scrubber systems must demonstrate compliance with all the guarantees for the wet scrubber and are included as part of the load tests described above. The rated capacity tests for individual modules include tests for sulfur dioxide removal efficiency, sulfur dioxide emissions, particulate emissions, and pressure loss at a flue gas flow rate close to the design flow of 2,613,000 lb/h. The rated capacity tests for the modules were conducted during the second week of testing, June 8, 1987 for Unit 1 and July 13, 1987 for Unit 2. During each rated capacity test the units operated at approximately 75 percent MCR. Unit 1 rated capacity tests included Modules B, C, D, E, and F. Unit 2 rated capacity tests included Modules A, B, C, D, E, and F.

2.2 UNIT 1 TESTS

2.2.1 Operating Conditions

In general, for the unit load tests, the Unit 1 wet scrubber system was tested at flue gas flows and temperatures which exceeded the specified design conditions. Only the 100 percent MCR gas flow was less than the design flow. All of the gas flows measured at the other load points exceeded the design flows, especially those measured during the 25 percent MCR tests. All of the measured inlet gas temperatures exceeded the maximum design temperatures. In contrast, however, sulfur dioxide loadings to the wet scrubber were less than the design loadings for all of the tests. The high gas flows are attributed to high excess air operation of the steam generator.

For the rated capacity tests of individual scrubber modules, the measured gas mass flows were very close to the rated design flow of 2,613,000 lb/h.

2.2.2 Test Results

Results of the Unit 1 wet scrubber load tests are shown in Table 2-1. The following summarizes the test results.

- The Unit 1 wet scrubber was in compliance with guarantees for SO_2 emissions, particulate emissions, opacity, pressure loss, stoichiometry ratio, and limestone consumption.
- Measurements of SO_2 removal efficiency satisfied the guarantee for the 100 and 25 percent MCR load tests. The removal efficiencies at 75 and 50 percent MCR did not comply with the guarantee. However, the low removal efficiencies were attributed to incorrect data used to tune the wet scrubber prior to these tests. Based on the information available, the system is believed to have sufficient capability to achieve the SO_2 removal efficiency guarantee at 75 and 50 percent MCR.

TABLE 2-1. UNIT 1 GUARANTEED VALUES VERSUS MEASURED VALUES

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured
SO_2 Emission, lb/MBtu	0.150	0.073	0.150	0.094	0.150	0.106	0.150	0.059
SO_2 Removal Efficiency, percent	90.00	91.98	90.00	88.99	90.00	88.51	90.00	93.26
Particulate Emission, lb/MBtu	0.0200	0.0028	0.0200	0.0046	0.0200	0.0028	0.0200	0.0031
Opacity, percent	20	3.6	20	3.5	20	3.4	20	3.5
Pressure Loss, in. wc	4.10	3.62	2.15	2.32	1.80	2.64	1.30	3.83
Stoichiometric Ratio								
mole calcium/mole SO_2 removed	1.08	1.03	1.08	1.04	1.08	1.03	1.08	1.04
Limestone Consumption, lb/h	21,370	17,900	10,580	7,300	7,280	6,690	2,960	2,630
Water Consumption, gpm	1,178	610	700	480	382	360	180	270
Power Consumption, kW								
6,900 V	3,718	2,850	2,724	2,160	1,801	1,450	1,196	970
480 V	312	335	312	335	267	335	223	335

- The scrubber satisfied all water consumption guarantees except at the 25 percent MCR load point. However, the 25 percent MCR test conditions deviated from the design conditions to such an extent that the test results for water consumption are inconclusive.
- Measurements of 6,900 volt power consumption were below the guaranteed values. Measurement of 480 volt power consumption exceeded the guarantees at all load points. However, total power consumption (6,900 volt plus 480 volt power) was well below the total guaranteed power consumption at all unit loads.
- Scrubber module pressure losses measured during the rated capacity tests significantly exceeded the guarantee.

2.3 UNIT 2 TESTS

2.3.1 Operating Conditions

The operating conditions observed for the Unit 2 wet scrubber tests were similar to those observed for the Unit 1 tests. With the exception of the 100 percent MCR tests, all of the gas flows measured for the unit load tests were greater than the design flows. In addition, the inlet gas temperatures exceeded the maximum design temperatures for all of the tests. In contrast with the Unit 1 tests, with the exception of the 100 percent MCR tests, all of the SO_2 loadings to the wet scrubber exceeded the design loadings. The excessive gas flows were attributed to high excess air operation of the steam generator.

As with the Unit 1 tests, the flue gas mass flows measured during the Unit 2 rated capacity tests were close to the design rated capacity flow.

2.3.2 Test Results

Results of the Unit 2 wet scrubber tests are shown in Table 2-2. The following provides a summary of the test results.

TABLE 2-2. UNIT 2 GUARANTEED VALUES VERSUS MEASURED VALUES

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured
SO_2 Emission, lb/MBtu	0.1500	0.074	0.1500	0.090	0.1500	0.082	0.1500	0.068
SO_2 Removal Efficiency, percent	90.00	91.50	90.00	90.73	90.00	91.53	90.00	92.51
Particulate Emission, lb/MBtu	0.0200	0.0053	0.0200	0.0041	0.0200	0.0017	0.0200	0.0019
Opacity, percent	20	1.3	20	1.6	20	1.6	20	1.6
Pressure Loss, in. wc	4.10	3.18	2.15	2.12	1.80	2.66	1.30	3.17
Stoichiometric Ratio								
mole calcium/mole SO_2 removed	1.08	1.03	1.08	1.05	1.08	1.02	1.08	1.01
Limestone Consumption, lb/h	21,370	11,600	10,580	11,500	7,280	3,400	2,960	3,800
Water Consumption, gpm	1,178	667	700	608	382	415	180	243
Power Consumption, kW								
6900 V, kV	3,718	2,930	2,724	2,240	1,801	1,510	1,196	1,000
480 V, kV	312	330	312	330	267	330	223	333

- The Unit 2 wet scrubber was in compliance with guarantees for SO_2 emissions, SO_2 removal efficiency, particulate emissions, opacity, stoichiometric ratio, and limestone consumption.
- The system pressure loss at 100 percent MCR did not meet guarantee based on the pressure loss correction curve contained in the contract. Pressure losses measured during the remaining unit load tests satisfied the guarantee.
- The measured 75 percent MCR limestone consumption rate was marginally within guarantee.
- Water consumption for the 100 and 75 percent MCR load tests was less than the guaranteed values. The 50 and 25 percent MCR water consumption rates exceeded the guarantee. However, as indicated with the Unit 1 tests, the test conditions exceeded the design conditions to such an extent that the test results for water consumption are inconclusive.
- The scrubber satisfied all guarantees for 6,900 volt power consumption. However, as observed during the Unit 1 tests, measurement of 480 volt power consumption exceeded the guarantees for all load tests. However, the combined power requirement for both the 6,900 volt and 480 volt equipment was well below the total guaranteed power.
- Individual module pressure losses at rated capacity conditions significantly exceeded the guarantee.

3.0 ANALYSIS OF RESULTS

This section presents a discussion of contract guarantees, the calculation procedures used for analyzing results, and the results of both the Units 1 and 2 performance tests.

3.1 MEASUREMENT AND CALCULATION PROCEDURES

Measurements and calculations to determine conformance with performance guarantees for the wet scrubber were obtained by operation of the steam generator while burning coal with properties within the ranges which are typically expected over the life of the units. Two sets of tests were conducted on each wet scrubber system, a series of unit load tests and rated capacity tests.

Unit load tests were conducted at 100, 75, 50, and 25 (or lowest attainable load) percent of maximum continuous rating (MCR) for verification of overall system guarantees. The results of these tests are discussed in Subsections 3.2.1 and 3.3.1 for Units 1 and 2, respectively.

Rated capacity tests of the wet scrubber system and individual modules were also conducted. Rated capacity of the wet scrubber is the ability of the overall system and the individual modules to comply with guaranteed performance while operating at the intended design capacity of the equipment. The rated capacity tests for the entire system must demonstrate compliance with all the guarantees for the wet scrubber, and are included in the 100 percent MCR unit load test. To measure the rated capacity of individual modules, the units were operated at approximately 75 percent MCR to achieve a gas flow rate close to the design flow rate. The Unit 1 rated capacity tests included Modules B, C, D, E, and F. The Unit 2 rated capacity tests included Modules A, B, C, D, E, and F. The results of the module rated capacity tests are included in Subsections 3.2.2 and 3.3.2 for Units 1 and 2, respectively.

3.1.1 Gas Flow and Density

The gas flow and density at the wet scrubber inlet are defined as the average of the flow measured directly by the testing contractor and the flow estimated by stoichiometric combustion calculations using the coal analysis and the estimated coal flows to the pulverizers.

The gas flow was measured by traverses in the scrubber inlet and chimney using an S-type pitot tube. Gas density was measured using EPA Methods 2, 3, and 4 CFR Title 40, Part 60, Appendix A. Three determinations of density and flow were conducted at the scrubber inlet and three determinations at the environmental monitoring platform of the chimney.

Measurements of flue gas flow at the chimney are expected to provide more accurate results than measurements at the wet scrubber inlet or outlet ducts. The relatively long and straight length of ductwork from the chimney liner elbow at the base of the chimney to the environmental platform allows the flue gas to develop a uniform velocity profile which should be relatively free of recirculating, or reverse, flows. In contrast, the sampling locations at the wet scrubber inlet and outlets are very close to bends and turns in the ductwork. Consequently, the gas flow at these locations will likely be very turbulent with recirculation, significantly reducing the accuracy of flow measurements at these locations.

Gas flow measurements at the chimney were related to the corresponding flow at the wet scrubber inlet by using carbon dioxide as the tie-component. By assuming that the flow of carbon dioxide is the same at the chimney and the wet scrubber inlet, the total flow of gas was estimated at the inlet by using the measured inlet gas compositions.

The gas flow estimated from the stoichiometric calculations was based on analyses of composite coal samples taken during the wet scrubber performance test and on differential coal counter readings at each operating pulverizer to establish the fuel heat input rates. These estimated stoichiometric flows were adjusted for excess air by using the oxygen concentrations measured by the testing contractor at the inlet to the wet scrubber. The oxygen content used for adjusting the stoichiometric flows was the average of the three trial measurements taken by the gas testing contractor during each test. The stoichiometric gas flow for each test is the arithmetic average of the three calculated trial flows.

The gas density was based on the stoichiometric calculations using the following equation.

$$\text{Gas density, lb/ft}^3 = \frac{P*M}{R*T},$$

where

P = absolute gas pressure, in. Hg abs,

M = molecular weight of gas, lb/lb-mole,

R = 21.8 ft^3 in. Hg/lb-mole R, and

T = absolute gas temperature, R.

3.1.2 Particulate Emissions

EPA Method 17, Determination of Particulate Emissions From Stationary Sources (In-Stack Filtration Method), as contained in 40 CFR 60, Appendix A was used at the stack to determine the particulate emissions, and was used at the inlet to the scrubber system to verify operating conditions. Method 17 uses a glass fiber filter to collect suspended particulate from a measured volume of flue gas for determination of particulate concentration. The average particulate concentration was determined for each trial. The particulate emission rate was determined by taking the product of the measured particulate concentrations and the F-factor. The F-factor was determined based on the ultimate analysis of a composite coal sample taken during each trial. For comparison with the guarantee, the particulate emission rate was calculated to be the average of the three trial values at each unit load, as determined using the F-factor method described above. Calculation of F-factor is discussed in Subsection 5.2.1 of the Test Plan. The ultimate analysis of the composite coal samples is presented in the Interpoll, Inc. test report.

The particulate emission rates were checked by taking the average flue gas flow, multiplying by the measured particulate concentration, and dividing by the heat input to the steam generator estimated by monitoring the coal burn rates. The average flue gas flow was the average of the measured gas flow and the stoichiometric gas flow adjusted for excess air. The average heat input to the steam generator was based on the average heating value of coal samples taken during the tests and the total measured coal burn rate over the test period.

For comparison with the guarantee, the particulate emission rate was calculated to be the average of the three trial values at each unit load determined using the F-factor method described above. The particulate emission rates based on estimated heat input to the steam generator were used only to check the accuracy of the emission rates determined using the F-factor. Refer to Subsection 2.1.3 of the Test Plan for a detailed description of the calculations.

3.1.3 Sulfur Dioxide Emission

Emissions of SO_2 from the wet scrubber are guaranteed not to exceed 0.150 lb/MBtu of heat input to the steam generator. This guarantee is valid for any flue gas flow produced by operation of the steam generator at any condition from 25 to 100 percent of maximum continuous rating (MCR), and with any flue gas temperature, flow condition, inlet particulate loading, or SO_2 loading within the design ranges listed in Tables 3-1 and 3-5.

Sulfur dioxide emission rates were measured at the inlet plenum of the wet scrubber system and at the chimney using Method 6, Determination of Sulfur Dioxide Emissions for Stationary Sources, as contained in 40 CFR Part 60, Appendix A. Emission rate expressed as pounds per million Btu was calculated using the F-factor method described in EPA Method 19 and measured ultimate analyses of composite coal samples.

As a check of the SO_2 emission rates calculated by the F-factor method, SO_2 emissions were also determined by taking the average flue gas flow, multiplying by the measured SO_2 concentration for each test, and dividing by the heat input rate to the steam generator estimated by monitoring coal flow rates to the pulverizers. The average gas flow for each trial was determined by averaging the measured gas flow and the calculated stoichiometric gas flow adjusted for excess air. Heat input to the steam generator was estimated by monitoring coal flows and composition over the duration of the test. Periodic composite coal samples were taken and analyzed to establish their heating value and for calculating flue gas flow based on composition. The average heat input to the steam generator was based on the average fuel heating value and the total measured coal burn rate over the test period.

For comparison with the guarantee, the average SO_2 emission rate was determined to be the average of the emission rates measured during the three trials at each unit load. Only the emission rates determined using the F-factor method were used to verify conformance with the guarantee. For a detailed description of the calculations, refer to Subsection 2.1.1 of the Test Plan.

3.1.4 Sulfur Dioxide Removal Efficiency

The SO_2 removal efficiency is guaranteed to be a minimum of 90 percent at any steam generator load between 25 percent and 100 percent MCR, with any design flue gas condition within the range and any coal with properties within the ranges stated listed in Appendix A of the Test Plan. The guarantee is not restricted by the composition or characteristics of the particulate matter entering the scrubber.

The SO_2 removal efficiency was determined by measuring SO_2 concentrations at the inlet plenum of the wet scrubber system and at the chimney using Method 6, Determination of Sulfur Dioxide Emissions from Stationary Sources, as contained in 40 CFR Part 60, Appendix A.

The following equation was used to determine the SO_2 removal efficiency.

$$SO_2 \text{ removal efficiency, percent} = \frac{C_i - C_o}{C_i} \times 100 \quad ,$$

where

C_i = inlet SO_2 concentration, ppm dry, and

C_o = outlet SO_2 concentration, ppm, dry.

3.1.5 Temperature

The temperature of the flue gas entering the wet scrubber system was measured by the gas testing contractor at the inlet plenum.

3.1.6 Limestone Quality

Limestone slurry samples were taken from the limestone additive feed recirculation piping. Solids filtered from these samples were analyzed for weight percent calcium carbonate, magnesium carbonate, and inert material. Carbonate content was analyzed by Interpoll, Inc. using EPRI Method 43, "Analysis of Carbonate in Slurry Liquor, Solids and Limestone Samples by the CO_2 Evolution Barium Hydroxide Absorption Method." Calcium and magnesium content were determined by EPRI Method 23, "Calcium magnesium, Sodium, Potassium, Iron, and Manganese Analyses by Atomic Absorption Spectrophotometry."[4]

3.1.7 Opacity

The opacity from the wet scrubber system is guaranteed not to exceed 20 percent at the chimney exit with any flue gas temperature, inlet particulate or SO_2 loading, or design flue gas flow within the ranges stated in the test plan. Opacity was measured at the chimney by transmissometers installed in each chimney liner. Opacity at the chimney was monitored and recorded on the environmental computer for the duration of all tests at all load points. The highest opacity reading (based on the six-minute averages printed by the environmental computer) for each test was used as the basis for determining compliance with the guarantees.

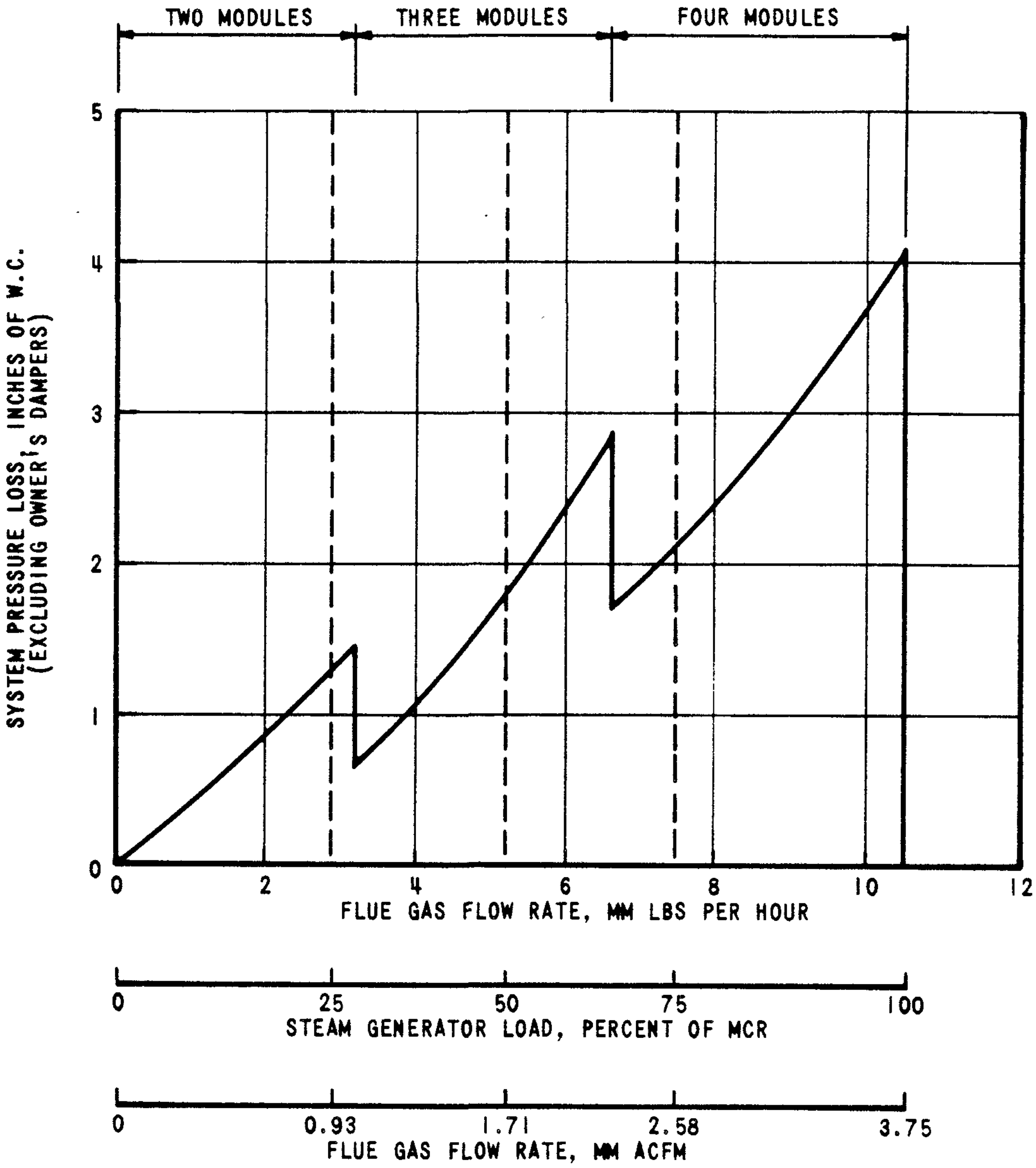
3.1.8 Pressure Loss

3.1.8.1 System Pressure Loss. Pressure loss across the flue gas wet scrubber system is guaranteed not to exceed 4.1 in. wc at 100 percent MCR, 2.15 in. wc at 75 percent MCR, 1.8 in. wc at 50 percent MCR, and 1.3 in. wc at 25 percent MCR. In addition, when an individual module is operating at rated capacity (25 percent of gas flow at MCR, up to 2,613,000 lb/h), the pressure loss is guaranteed not to exceed 2.54 in. wc across the module.

Pressure loss was measured by Interpoll, Inc. as part of the sampling procedures for the SO_2 and particulate emission tests. At the beginning of each trial, a velocity traverse was conducted in accordance with Method 2, Determination of Stack Gas Velocity and Volumetric Flow Rate, of 40 CFR Part 60 Appendix A. The inlet static pressure was determined at each traverse point by orienting the S-type pitot tube directly into the flow and then measuring both total and velocity pressure. The velocity pressures were then corrected for the pitot tube calibration coefficient back to true velocity pressures and subtracted from the total pressure to give the static pressure. The average inlet static pressure was determined by averaging the static pressures calculated at each traverse point. The outlet static pressure was measured directly by using a static pressure probe developed by Interpoll, Inc. The pressure probe was used at the system outlets to avoid the extreme difficulty of measuring static pressure at this point with a pitot tube traverse. The average outlet static pressure was calculated as the average of 25 static pressure measurements across the system outlet duct. The average inlet and outlet static pressures from each test were used to calculate pressure loss.

These values were then compared with the pressure drop at the design gas flow by use of the pressure loss correction curve shown on Figure 3-1. For each system performance test, the measured pressure loss at respective average gas flow is compared with the curve shown on Figure 3-1. If the measured points are below the curve, then the system is in compliance with the guarantee. If the points are above the curve, the measured pressure losses do not conform with the guarantees.

IPP-P-1057
SYSTEM PRESSURE LOSS VS FLUE GAS FLOW RATE



BASIS: FLUE GAS PER B&V'S SPECIFICATION
TABLES 2A.6.5, 2A.10.1

PRESSURE LOSS CORRECTION CURVE
FOR THE WET SCRUBBER

FIGURE 3-1

3.1.8.2 Module Pressure Loss. Pressure drop across individual modules is guaranteed to be not greater than 2.54 in. wc at the rated capacity flow of 2,613,000 lb/h.

The pressure loss for individual modules was measured during the rated capacity tests by Interpoll, Inc. using the S-type pitot tube method described above for the system inlets. To correct for deviations from the rated capacity design flow, the measured pressure losses were adjusted by the following equation, assuming uniform distribution of the measured flue gas flow to the wet scrubber modules.

$$P_1 = P_2 \left[\frac{V_D}{D_D\ (60)\ (V_M)}\right]^2 \quad X \quad \frac{(D_D)}{D_M} ,$$

where

P_1 = adjusted pressure loss, inches of water,
P_2 = measured pressure loss, inches of water,
V_D = design inlet gas flow, lb/h,
D_D = design inlet gas density, lb/ft^3,
V_M = average gas flow to each module, acfm, and
D_M = measured inlet gas density, lb/ft^3.

3.1.9 Stoichiometric Ratio

The wet scrubber system stoichiometric ratio is guaranteed not to exceed 1.08 moles of calcium per mole of sulfur removed at all steam generator loads. The stoichiometric ratio was determined from chemical analyses performed on solids samples from the scrubber blowdown slurry for calcium as calcium carbonate, calcium as calcium sulfite, and calcium as calcium sulfate. The stoichiometric ratio was calculated as the sum of the moles of calcium as calcium carbonate, calcium sulfite, and calcium sulfate divided by the sum of the moles of calcium as calcium sulfite and calcium sulfate.

Two samples of scrubber slurry were taken from the scrubber blowdown piping at the discharge into the thickener feed mix tank during each trial for a total of six samples for each unit load test (25, 50, 75, and 100 percent MCR). The samples were filtered, washed, dried, and preserved for analysis.

The sum of the moles of calcium carbonate, calcium sulfate, and calcium sulfite were assumed to be equal to the total moles of calcium in the scrubber sludge. The total moles of calcium were determined by using the procedures described in EPRI Method 23 as described in Subsection 3.1.6. The sum of the moles of calcium sulfate, and calcium sulfite was assumed to be equal to the total moles of sulfur in the scrubber sludge. Total moles of sulfur were measured by EPRI Method 27, "Analysis of Anions (Fluoride, Chloride, Sulfite, Sulfate, and Phosphate) in Scrubber Liquors and Solids by Ion Chromatography with Modified Anion Effluent."

3.1.10 Limestone Consumption

The limestone consumption by the wet scrubber system is guaranteed not to exceed 21,370 lb/h at 100 percent MCR, 10,580 lb/h at 75 percent MCR, 7,280 lb/h at 50 percent MCR, and 2,960 lb/h at 25 percent MCR.

Limestone consumption was calculated using two methods. The first method uses the stoichiometric ratio and the rate of SO_2 removal in the wet scrubber. The second method involves monitoring of the limestone slurry storage tank level to estimate limestone consumption over the duration of each test.

To calculate limestone consumption based on stoichiometric ratio, the following equation was used.

$$\text{Limestone consumption, lb/h} = \frac{SR \times MSO_2}{(1 - INT)} \times 1.562 \quad ,$$

where

SR = stoichiometric ratio, moles CA/mole SO_2 removed,
MSO_2 = SO_2 removal rate, lb/h, and
INT = inert material in limestone, weight fraction.

Estimation of limestone consumption using differential limestone slurry storage tank levels is calculated using the following equation.

$$\text{Limestone consumption, lb/h} = \frac{L_T \times SG \times \%S \times 8.345}{T},$$

where

L_T = change in tank level, ft,

SG = specific gravity of slurry,

%S = weight percent solids in limestone slurry, and

T = time duration of trial, h.

Six limestone slurry samples were taken from the limestone slurry feed supply. The samples were analyzed for weight percent solids onsite by Black & Veatch personnel.

3.1.11 Water Consumption

The wet scrubber water consumption is guaranteed not to exceed 1,750 gpm at 100 percent MCR, 700 gpm at 75 percent MCR, 382 gpm at 50 percent MCR, and 180 gpm at 25 percent MCR.

The calculation of scrubber makeup water by the wet scrubber system is calculated by summing the flows for mist eliminator wash water, wet scrubber seal water, and the portion of makeup water contained in the limestone additive slurry water. The sum is then divided by the time duration of the trial.

As discussed in the Test Plan, the fraction of scrubber makeup water contained in the limestone additive slurry water should also be included in the measurement of scrubber water consumption. However, flow data for determining this fraction was not taken during limestone preparation system operation. Consequently, measurements of water consumption are likely slightly lower than actual values.

3.1.12 Electrical Power

Power consumption by the wet scrubber is guaranteed for both 6,900 volt and 480 volt three-phase service. The guarantees are listed in Tables 3-2 and 3-6 and are discussed in the Test Plan. Power consumption was measured by watt-hour meters placed on the 6,900 volt and 480 volt electrical feeders to specific motors included in the Power Guarantee User's List in the wet scrubber contract. The loads used to determine the power consumption guarantees include the motors for the scrubber spray pumps, limestone slurry pumps, mist eliminator wash pumps, limestone slurry storage tank mixers, reaction tank mixers, and reheater soot blowers. Power consumption of specific motors was measured by IPSC personnel independently from the wet scrubber performance tests. These measurements are presented in Appendix B.

Total power consumption by the wet scrubber and limestone preparation systems was calculated by summing the average measured power usage of specific component items in the Power Guarantee User's List. The average power for a specific component was calculated by averaging all of the power usage measurements for similar components. For example, the average power consumption for the high-pressure spray pumps was determined by averaging the power usage measured for all six high-pressure spray pumps.

The power consumed by the scrubber spray pumps and the limestone pulverizer motors was adjusted to reflect the differences between the actual motor efficiencies and horsepowers and those assumed for development of the power consumption guarantees. The following compares the assumed values with the actual values for efficiency and horsepower.

Motor	Assumed Values		Actual Values	
	Horsepower	Efficiency percent	Horsepower	Efficiency percent
Scrubber HP Spray Pump	450	94.3	500	94.7
Scrubber IP Spray Pump	400	94.3	500	94.7

Motor	Assumed Values Horsepower	Efficiency percent	Actual Values Horsepower	Efficiency percent
Scrubber LP Spray Pump	400	94.1	500	94.7
Limestone Pulverizer	600	94.7	600	95.2

To adjust the power consumption values measured for the spray pumps and limestone pulverizers, the average measured power was multiplied by the ratio of the actual efficiency to the assumed efficiency.

3.2 UNIT 1 TEST RESULTS

3.2.1 Load Tests

Verification of performance guarantees for the wet scrubber system required simultaneous measurement of flow, density, and composition of selected gas, slurry, and water streams. The following subsections provide the results of the Unit 1 load tests at 100, 75, 50, and 25 percent MCR.

The operating conditions for the Unit 1 load tests are compared with the design conditions on Table 3-1. Gas flow for the 100 percent MCR test was below the design gas flow. The gas flows measured for the 75, 50, and 25 percent gas flows exceeded the design flows, especially in the case of the 25 percent MCR load test. All of the inlet gas temperatures exceeded the maximum design temperatures. Consequently, all of the measured inlet gas densities were lower than the corresponding design values. Sulfur dioxide loading to the Unit 1 wet scrubber system were all less than the design loadings.

The high gas flows at the 75, 50, and 25 percent loads are primarily due to high excess air operation of steam generator. It should be noted that the heat input to the steam generator was also higher than the design values for the 75, 50, and 25 percent MCR load points, indicating

TABLE 3-1. UNIT 1 OPERATING CONDITIONS

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Design	Measured	Design	Measured	Design	Measured	Design	Measured
Unit Load, MW	840	843	630	650	420	434	210	267
Heat Input, MBtu/h	8,352	8,050	6,142	6,350	4,248	4,450	2,190	3,030
Total Flue Gas Flow, lb/h	10,456,000	9,877,000	7,508,000	8,352,000	5,192,000	6,817,000	2,916,000	5,254,000
Flue Gas Inlet Temperature, F								
Nominal	285	308	255	297	220	265	200	236
Minimum	255	--	225	--	190	--	170	--
Maximum	305	--	285	--	250	--	225	--
Flue Gas Density, lb/cu ft	0.0465	0.0457	0.0485	0.0458	0.0510	0.0477	0.0525	0.0496
SO_2 Loading, lb/h	12,530	7,450	6,165	5,510	4,240	4,290	2,723	2,720
Number of Scrubber Modules in Service	4	4	4	4	3	3	2	2
Number of Scrubber Spray Pumps in Service	12	12	8	8	6	6	6	6

lower unit efficiencies at these points due to the high air flows. The higher heat inputs correspond to higher fuel burn rates, which also would increase the flue gas flow.

3.2.1.1 SO_2 Emissions. The SO_2 emission rates measured during the Unit 1 load tests are shown in Table 3-2. The SO_2 emission rates for all loads were below the guarantee of 0.15 lb/MBtu. The SO_2 emission levels ranged from 0.059 to 0.106 lb/MBtu.

As discussed in Section 3.1, SO_2 emission rates were measured using the F-factor method and the coal flow method. Only the emission rates determined by the F-factor method are used for comparison with the guarantees; however, comparison of the rates measured by both methods will validate the accuracy of SO_2 emission tests.

Table 3-3 presents the SO_2 emission rates determined using both the F-factor and coal flow methods. The emission rates based on coal flow were consistently 15 to 17 percent higher than those determined by the F-factor method, ranging from 0.068 to 0.124 lb/MBtu. However, the relative trend between the unit load points was the same for both methods. Additionally, all of the SO_2 emission rates measured by the coal flow method were less than the guarantee. Consequently, the SO_2 emission rate measurements appear to be reasonable and accurate.

3.2.1.2 SO_2 Removal Efficiency. The SO_2 removal efficiencies observed during the Unit 1 load tests are shown in Table 3-2. Only the 100 percent and the 25 percent MCR tests met the performance guarantee. The two other cases did not meet the guaranteed performance level. The 75 percent MCR SO_2 removal efficiency was 88.99 percent and the 50 percent MCR SO_2 removal efficiency was 88.51 percent.

The low removal efficiencies for the 75 and 50 percent MCR tests appear to be the result of inaccurate SO_2 concentration measurements by the continuous emissions monitoring system. Prior to each test, the unit load was decreased to the appropriate operating point. On request of GEESI, the pH set points for the wet scrubber were adjusted to achieve an acceptable SO_2 removal efficiency based on the efficiencies output from

TABLE 3-2. UNIT 1 GUARANTEED VALUES VERSUS MEASURED VALUES

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured
SO_2 Emission, lb/MBtu	0.150	0.073	0.150	0.094	0.150	0.106	0.150	0.059
SO_2 Removal Efficiency, percent	90.00	91.98	90.00	88.99	90.00	88.51	90.00	93.26
Particulate Emission, lb/MBtu	0.0200	0.0028	0.0200	0.0046	0.0200	0.0028	0.0200	0.0031
Opacity, percent	20	3.6	20	3.5	20	3.4	20	3.5
Pressure Loss, in. wc	4.10	3.62	2.15	2.32	1.80	2.64	1.30	3.83
Stoichiometric Ratio								
mole calcium/mole SO_2 removed	1.08	1.03	1.08	1.04	1.08	1.03	1.08	1.04
Limestone Consumption, lb/h	21,370	17,900	10,580	7,300	7,280	6,690	2,960	2,630
Water Consumption, gpm	1,178	610	700	480	382	360	180	270
Power Consumption, kW								
6,900 V	3,718	2,850	2,724	2,160	1,801	1,450	1,196	970
480 V	312	335	312	335	267	335	223	335

TABLE 3-3. COMPARISON OF MEASURED PARAMETERS AND CHECK VALUES FOR UNIT 1 LOAD TESTS

Parameter	100 Percent MCR	75 Percent MCR	50 Percent MCR	25 Percent MCR
SO_2 Emission Rate, F-factor Method, lb/MBtu	0.073	0.094	0.106	0.059
SO_2 Emission Rate, Coal Flow Method, lb/MBtu	0.085	0.110	0.124	0.068
Particulate Emission Rate, F-Factor Method, lb/MBtu	0.0028	0.0046	0.0028	0.0031
Particulate Emission Rate, Coal Flow Method, lb/MBtu	0.0028	0.0046	0.0029	0.0031
Limestone Consumption, Tank Level Method, lb/h	17,900	7,300	6,690	2,630
Limestone Consumption, Stoichiometric Ratio Method, lb/h	11,600	8,600	6,640	4,460

the continuous monitoring system. However, the monitoring system was incorrectly calibrated, and thus was not measuring accurate removal efficiencies. This problem is discussed in more detail in Subsection 3.2.3.

3.2.1.3 Particulate Emissions. The particulate emission rates observed during the Unit 1 load tests are shown in Table 3-2. All tested loads met the performance guarantee of 0.020 lb/MBtu. The measured particulate emission rates were significantly lower than the guarantee and ranged from 0.0028 to 0.0046 lb/MBtu.

As with the SO_2 emission rates, particulate emission rates determined using the F-factor method were checked by calculating emission rates based on coal flow, gas flow, and particulate concentration. Table 3-3 compares the particulate emission rates determined using both methods. The particulate emission rates based on coal flows are almost identical to those based on the F-factor. Consequently, the measured particulate emission rates appear to be accurate determinations of the actual particulate emissions from the wet scrubber.

3.2.1.4 Opacity. The opacities measured during the Unit 1 load tests were all under the 20 percent guarantee. The opacity measured at the chimney ranged from 3.35 percent for the 50 percent load test to 3.64 percent for the 100 percent load test.

3.2.1.5 Minimum Load Operation. The flue gas wet scrubber is guaranteed to operate satisfactorily and reliably for extended periods at the minimum attainable load of the steam generator, or 25 percent MCR, whichever is higher. During the 25 percent load test on Unit 1, the measured unit load was 267 MW gross which is 57 MW greater than the 25 percent MCR load of 210 MW. This was the lowest attainable stable load of the steam generators. The wet scrubber operated stably at this load condition for the duration of the parameter tests and would appear to be in compliance with this guarantee.

3.2.1.6 Pressure Loss. The pressure losses measured for the Unit 1 load tests are presented in Table 3-2. The measured pressure losses for the 75, 50, and 25 percent load tests indicate that the system does not meet guarantee at these loads. However, the flue gas flows which corresponded to the pressure losses significantly exceeded the design flows at the respective load points. Therefore, the pressure loss correction curve (shown on Figure 3-1) must be used to evaluate compliance with the guarantee.

By plotting the measured pressure losses with the corresponding flue gas mass flow rates on the pressure loss correction curve, compliance with the guarantee is determined depending on whether the point is above or below the correction curve. The pressure losses for both the 100 and 75 percent MCR cases are within compliance with the guarantee. For the 50 percent MCR case, the wet scrubber was operated with three modules in service; however, the measured flue gas flow exceeded the transition flow from three to four operating modules. The wet scrubber was operated with fewer modules in service than intended at that gas flow. However, if the three module curve is extrapolated beyond the transition point, the pressure loss at 50 percent MCR is clearly beneath the correction curve. A similar phenomenon exists for the 25 percent MCR test. The flue gas flow measured during the test is significantly beyond the transition point from two to three operating modules; however, only two modules were operated during this test. The operating point deviates significantly from the correction curve, preventing any accurate extrapolation of the correction curve to determine compliance with the guarantee. However, since the pressure losses at the other three load points are within compliance with the guarantees based on the correction curve, it is likely that the loss at 25 percent MCR would also be in compliance, provided the gas flow is maintained at a reasonable flow for two modules.

3.2.1.7 Stoichiometric Ratio. The stoichiometric ratios determined during the Unit 1 load tests were all within the limit of 1.08 moles calcium per mole of sulfur removed. The stoichiometric ratios ranged from 1.03 to 1.04 moles calcium per mole of sulfur removed. The measured values of stoichiometry are present in Table 3-2.

3.2.1.8 Limestone Consumption. The limestone consumptions for the Unit 1 load tests for the 100, 75, 50, and 25 percent load tests were all below the limestone consumption guaranteed value and are shown in Table 3-2.

The limestone consumption measurements shown in Table 3-2 are based on measurements of limestone slurry tank level and limestone slurry solids. The Test Plan discusses a check of limestone consumption based on SO_2 removal rate and measured stoichiometric ratio. Table 3-3 shows a comparison of the limestone consumption rates determined using both methods. With the exception of the 75 and 50 percent MCR tests, the limestone consumption based on stoichiometry deviates significantly from those based on differential tank level measurements. However, only the 25 percent MCR consumption rate based on stoichiometric ratio exceeds the guarantee. Although use of stoichiometric ratio to calculate limestone consumption would be expected to give a more accurate indication of the long-term performance of the system, the system would have to be operated at a relatively constant condition for an extended period of time to achieve an equilibrium condition. Since the scrubber was operated at extreme conditions (excessive gas flows) for only a short period of time, the measured stoichiometric ratios for the 25 percent MCR test probably are not an accurate indicator of system performance at those conditions.

3.2.1.9 Water Consumption. The water consumption rates for the 100, 75, and 50 percent MCR load tests for Unit 1 were below the guaranteed values. The 25 percent load test water consumption value of 266 gpm exceeded the guaranteed value of 180 gpm. Values for water consumption are shown in Table 3-2. Noncompliance of the 25 percent MCR test is discussed in Subsection 3.2.3.

3.2.1.10 Power Consumption. The power consumption by the wet scrubber is guaranteed for both 6,900 volt and 480 volt three-phase service. Measurements of power consumption for 6,900 volt service were significantly below the guarantee values for all loads. However, power consumption for 480 volt service exceeded the guarantee for all unit load points. Table 3-2 shows the 6,900 and 480 volt power consumption data.

In determining power consumption, the following assumptions were made.

- Limestone slurry tank agitator power for Unit 1 was not measured. Consequently, the Unit 1 agitator power was assumed to be the same as that measured for Unit 2.
- Limestone slurry pump power consumption was not measured for Unit 1 or Unit 2. Therefore, limestone slurry pump power was assumed to be equal to the power requirement listed on the Power Guarantee User's List in the contract.
- All six reaction tank agitator motors were assumed to be operated, and were included in calculating the 480 volt power consumption.

The exceedance of the 480 volt guarantee appears to be primarily due to the inclusion of all of the operating reactor tank agitators in calculating the power requirement. This noncompliance is addressed further in Subsection 3.2.2.

3.2.2 Rated Capacity Tests

The rated capacity of the wet scrubber is the ability of the overall system and the individual modules to operate within guaranteed performance, and within the intended design capacity of the equipment. Rated capacity of the wet scrubber system was confirmed in the 100 percent MCR load test. Individual modules were monitored to comply with guarantees for sulfur dioxide emission rate and removal efficiency, particulate emission rate, and pressure loss. The six wet scrubber modules were tested in groups of three with the unit operating at approximately 75 percent MCR. Unit load and excess air were adjusted to closely approximate the design rated capacity flows assuming an even flow split between the three operating modules. Module E was tested twice, since Module A was inoperative and thereby excluded from the tests. The results are shown in Table 3-4.

3.2.2.1 <u>SO_2 Emissions</u>. The sulfur dioxide emission rates for all of the modules tested were below the guarantee value of 0.15 pound of SO_2 per million Btu. The average sulfur dioxide emission rate for Unit 1 rated capacity tests was 0.0593 pound per million Btu for Modules C, E, and F, and 0.0477 pound per million Btu for Modules B, D, and E.

3.2.2.2 <u>SO_2 Removal Efficiency</u>. The sulfur dioxide removal efficiency for the rated capacity tests ranged from 91.26 percent (Module F) to 94.73 percent (Module D). All of the modules met the guarantee value of 90 percent sulfur dioxide removal efficiency.

3.2.2.3 <u>Particulate Emissions</u>. The particulate emissions for all three tests were significantly below the guarantee value of 0.020 pound per million Btu. The average emission rates ranged between 0.0037 pound per million Btu (Modules B, D, and E) and 0.0046 pound per million Btu (Modules C, E, and F).

3.2.2.4 <u>Pressure Loss</u>. All the pressure losses observed during the Unit 1 rated capacity testing exceeded the guaranteed pressure loss of 2.54 inches of water. The pressure losses ranged from 3.79 inches of water (Module E) to 4.65 inches of water (Module E). All pressure losses listed in Table 3-4 have been corrected for flow rates that exceeded the guarantee flow of 2,613,000 lb/h. Appendix A summarizes the pressure losses adjustment calculations.

3.2.3 <u>Noncompliant Parameters</u>

The parameters that did not meet the guaranteed values for Unit 1 were as follows.

- SO_2 removal efficiency for 75 percent load and 50 percent load.
- Water consumption for 25 percent load.
- 480 volt power consumption at all load points.
- Pressure loss for the module rated capacity tests.

TABLE 3-4. SUMMARY OF RATED CAPACITY GUARANTEED PARAMETERS VERSUS MEASURED VALUES--UNIT 1

	Guarantee	Module C	Module E*	Module F	Module B	Module D	Module E*
Total Flue Gas Flow Rate, adjusted pounds per hour	2,613,000	2,628,813	2,628,813	2,628,813	2,660,997	2,660,997	2,660,997
SO_2 Removal Efficiency, percent	90.00	93.91	93.33	91.26	93.37	94.73	94.01
SO_2 Emission Rate, pounds per million Btu	0.150	0.0593	0.0593	0.0593	0.0477	0.0477	0.0477
Particulate Emission Rate, pounds per million Btu	0.020	0.0046	0.0046	0.0046	0.0037	0.0037	0.0037
Average Adjusted Pressure Loss, inches of water	2.54	4.31	4.65	4.56	4.62	4.62	4.12

*Module was used twice.

The following subsections present discussions of the parameters which did not meet guarantee.

3.2.3.1 75 and 50 Percent MCR SO_2 Removal Efficiency. As discussed in Subsection 3.2.1.2, the SO_2 removal efficiencies at 75 and 50 percent MCR were 88.99 and 88.51 percent, respectively, and are lower than the 90 percent guarantee. The SO_2 continuous monitoring system was used as the basis for adjusting the reaction tank pH set points to achieve the 90 percent removal efficiency. However, the monitoring system was incorrectly calibrated, and was indicating higher removal efficiencies than were actually being achieved by the wet scrubber. Consequently, if an accurate reading of removal efficiency was available, the pH set point could have been raised to a level which satisfied to 90 percent removal guarantee. Noting that the measured limestone consumption rates and corresponding stoichiometric ratios were well within the guaranteed limits, it is likely that the wet scrubber was capable of achieving an additional 1 to 2 percent increase in removal efficiency without violating other guaranteed parameters. Therefore, the wet scrubber should be considered to be in full compliance with the SO_2 removal efficiency guarantee.

3.2.3.2 25 Percent MCR Water Consumption. The 25 percent MCR water consumption measurement was 270 gpm, 90 gpm greater than the guarantee of 180 gpm. Based on the operating conditions monitored for the 25 percent MCR load tests, the wet scrubber system was operated at conditions which significantly exceeded the design conditions, especially with respect to flue gas flow. It is difficult to extrapolate the impacts of excessive gas flow on water consumption; however, it is reasonable to assume to an excessive gas loading to the scrubber modules (and a corresponding increase in gas velocity through the modules) may increase the need for mist eliminator washing. However, given the data collected during the test, it is difficult to predict the rate of water consumption if the wet scrubber was operated at design conditions. Consequently, the results of the test are inconclusive as to whether or not the wet scrubber is in compliance with this guarantee.

3.2.3.3 480 Volt Power Consumption. As noted in Subsection 3.2.1.10, the 480 volt power consumption measurements exceeded the guarantee values at all load points. The measured consumption was 335 kW for all of the tests, which exceeded the 312 kW 100 percent MCR guarantee by 23 kW, and the 223 kW 25 percent MCR guarantee by 112 kW. All six of the reaction tank agitator motors were assumed to be operating when calculating the measured values. In contrast, the Power Consumption User's List in the contract assumes that the number of agitators which operate equals the number of operating modules. Consequently, the number of operating components used to establish the 480 volt power consumption guarantees appear to differ from the actual number of components which actually operate. It should also be noted that the power consumption guarantees for both 6,900 volt and 480 volt service cannot be verified using the values in the Power Consumption User's List.

The 6,900 volt power consumption measurements were significantly lower than the guarantee values. The total power consumption (6,900 volt plus 480 volt) for the wet scrubber is less than the sum of both power consumption guarantees. Consequently, even though the 480 volt guarantees have been exceeded, the wet scrubber system is consuming less auxiliary power than guaranteed in the contract. Therefore, noncompliance of the 480 volt power consumption measurements does not appear to be significant with respect to the overall system auxiliary power requirement.

3.2.3.4 Rated Capacity Module Pressure Loss. The pressure losses for individual scrubber modules significantly exceeded the guarantee at rated capacity conditions. The measured pressure losses ranged from 4.12 to 4.65 in. wc, compared with the guarantee of 2.54 in. wc. The measured gas flows during the rated capacity tests were very close to the design flow of 2,613,000 lb/h. Consequently, only slight adjustment of the actual measured pressure losses was required to determine the rated capacity losses. Therefore, the measurements appear to be accurate, and the wet scrubber is not in compliance with this guarantee.

3.3 UNIT 2 TEST RESULTS

3.3.1 Load Tests

The operating conditions for the Unit 2 load tests are compared with the design conditions in Table 3-5. As noted for the Unit 1 conditions in Section 3.2, only the 100 percent MCR gas flow was below the design gas flow. The flows at the other load points exceeded the design flows, especially the 25 percent MCR flows. All of the inlet gas temperatures exceeded the maximum design temperatures, and the corresponding inlet gas densities were also lower than the design values. The SO_2 loading for the 100 percent MCR test was below the original design loading, but the remaining loadings for the 75, 50, and 25 percent MCR tests were all higher than the design values.

As discussed for the Unit 1 tests, the observed fuel burn rates were higher for the 75, 50, and 25 percent load tests for Unit 2. This appears to be due to lower unit efficiencies resulting from high excess air operation. High excess air combined with higher fuel burn rates would explain the high gas flows measured for the 75, 50, and 25 percent MCR tests. The following subsections provide the results of the testing for conformation of performance for the wet scrubber system.

3.3.1.1 SO_2 Emissions. The SO_2 emission rates observed during the Unit 2 load tests are shown in Table 3-6. The SO_2 emission rates for all loads were well below the guarantee of 0.015 lb/MBtu. The SO_2 emission levels ranged from 0.0684 lb/MBtu for the 25 percent load test to 0.0899 lb/MBtu for the 75 percent load test. The SO_2 emission rates determined by the F-factor method are compared with those determined by the coal flow method in Table 3-7. The deviations noted for the SO_2 emissions rates determined using the coal flow method were consistently 15 to 17 percent higher than those determined by the F-factor method. This is identical to the results

TABLE 3-5. UNIT 2 OPERATING CONDITIONS

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Design	Measured	Design	Measured	Design	Measured	Design	Measured
Unit Load, MW	840	839	630	635	420	431	210	260
Heat Input, MBtu/h	8,352	7,770	6,142	6,010	4,248	4,140	2,190	2,720
Total Flue Gas Flow, lb/h	10,456,000	8,912,000	7,508,000	7,724,000	5,192,000	6,371,000	2,916,000	4,614,000
Flue Gas Inlet Temperature, F								
Nominal	285	325	255	294	220	257	200	240
Minimum	255	--	225	--	190	--	170	--
Maximum	305	--	285	--	250	--	225	--
Flue Gas Density, lb/cu ft	0.0465	0.0441	0.0485	0.0454	0.0510	0.0475	0.0525	0.0489
SO_2 Loading, lb/h	12,530	7,090	6,165	6,380	4,240	4,260	2,723	2,730
Number of Scrubber Modules in Service	4	4	4	4	3	3	2	2
Number of Scrubber Spray Pumps in Service	12	12	8	8	6	6	6	6

TABLE 3-6. UNIT 2 GUARANTEED VALUES VERSUS MEASURED VALUES

	100 Percent Load Test		75 Percent Load Test		50 Percent Load Test		25 Percent Load Test	
	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured	Guaranteed	Measured
SO_2 Emission, lb/MBtu	0.1500	0.074	0.1500	0.090	0.1500	0.082	0.1500	0.068
SO_2 Removal Efficiency, percent	90.00	91.50	90.00	90.73	90.00	91.53	90.00	92.51
Particulate Emission, lb/MBtu	0.0200	0.0053	0.0200	0.0041	0.0200	0.0017	0.0200	0.0019
Opacity, percent	20	1.3	20	1.6	20	1.6	20	1.6
Pressure Loss, in. wc	4.10	3.18	2.15	2.12	1.80	2.66	1.30	3.17
Stoichiometric Ratio								
mole calcium/mole SO_2 removed	1.08	1.03	1.08	1.05	1.08	1.02	1.08	1.01
Limestone Consumption, lb/h	21,370	11,600	10,580	11,500	7,280	3,400	2,960	3,800
Water Consumption, lb/h	1,178	667	700	608	382	415	180	243
Power Consumption, kW								
6900 V, kV	3,718	2,930	2,724	2,240	1,801	1,510	1,196	1,000
480 V, kV	312	330	312	330	267	330	223	333

TABLE 3-7. COMPARISON OF MEASURED PARAMETERS AND CHECK VALUES FOR UNIT 2 LOAD TESTS

Parameter	100 Percent MCR	75 Percent MCR	50 Percent MCR	25 Percent MCR
SO_2 Emission Rate, F-factor Method, lb/MBtu	0.074	0.090	0.082	0.068
SO_2 Emission Rate, Coal Flow Method, lb/MBtu	0.090	0.110	0.097	0.081
Particulate Emission Rate, F-factor Method, lb/MBtu	0.0053	0.0041	0.0017	0.0019
Particulate Emission Rate, Coal Flow Method, lb/MBtu	0.0055	0.0043	0.0018	0.0020
Limestone Consumption, Tank Level Method, lb/h	11,600	11,500	3,400	3,800
Limestone Consumption, Stoichiometric Ratio Method, lb/h	10,900	9,750	6,560	4,260

observed from the Unit 1 tests. As with the Unit 1 tests, all of the measurements were less than the guaranteed rate, and the coal flow based emission rates showed the same trend as the F-factor rates. Consequently, the SO_2 emission rate measurements appear to accurately reflect wet scrubber performance with respect to this guarantee.

3.3.1.2 SO_2 Removal Efficiency. The SO_2 removal efficiencies observed during the Unit 2 load tests are shown in Table 3-6. All of the load tests for SO_2 removal efficiency met the guaranteed performance level as required by contract. The range of SO_2 removal efficiency was 92.51 percent for the 25 percent load test to 90.73 percent for the 75 percent load test.

3.3.1.3 Particulate Emissions. The particulate emission rates observed during the Unit 2 load tests are shown in Table 3-6. All tested loads met the performance guarantee of 0.020 lb/MBtu. The particulate emission levels ranged from 0.0017 lb/MBtu for the 50 percent load test to 0.0053 lb/MBtu for the 100 percent load test.

The particulate emission rates measured using the coal flow method are compared with those determined using the F-factor method in Table 3-7. Only the particulate emission rates are compared with the guarantee values, but the emissions calculated using the coal flow method provide a good check for the F-factor emission rates. The emission rates based on coal are very close to those determined with the F-factor. Consequently, the particulate emission rate measurements appear to be accurate with a high degree of confidence.

3.3.1.4 Opacity. The opacities measurements during the Unit 2 load tests were all well under the 20 percent guarantee limit. The opacity from the wet scrubber system measured at the chimney ranged from 1.64 percent for the 75 percent MCR load test to 1.26 percent for the 100 percent MCR load test.

3.3.1.5 Minimum Load Operation. The flue gas wet scrubber is guaranteed to operate satisfactorily and reliably for extended periods at the minimum attainable load of the steam generator, or 25 percent MCR, whichever is higher. During the 25 percent load test on Unit 2, the unit load was 260 MW gross, which is 50 MW greater than the 25 percent load of 210 MW. The Unit 2 wet scrubber system was able to sustain stable operation for the duration of the 25 percent MCR load tests. Consequently, the system would appear to comply with the minimum load operation guarantee.

3.3.1.6 Pressure Loss. The pressure losses measured for the Unit 2 load tests are presented in Table 3-5. The losses measured for the 50 and 25 percent load tests indicate that the system does not meet guarantee at these loads. However, as discussed in Subsection 3.2.1.6 for the Unit 1 tests, the measured flue gas flows at these load points significantly exceed the corresponding design flue gas flows. Therefore, compliance with the guarantees must be determined by using Figure 3-1.

Plotting the measured pressure losses and corresponding mass flow rates on Figure 3-1, the guarantee at the unit load tests can be verified. The pressure losses at 100 percent and 25 percent MCR do not comply with the guarantee shown on the pressure correction curve. The values measured at 75 and 50 percent MCR are in compliance with the guarantee. For the 100 percent MCR test, the measured pressure loss is about 0.2 in. wc above the correction curve at 8,912,000 lb/h of flue gas flow. For the 25 percent MCR test, the same problem exists as observed with the Unit 1 tests. Two scrubber modules were operated during these tests, but the tested flue gas flow is significantly greater than the transition point from two to three operating modules. Consequently, the operating point deviates significantly from the correction curve, preventing any accurate extrapolation of the correction curve to determine compliance with the guarantee. Therefore, as concluded in the Unit 1 test, since the higher load (75 and 50 percent MCR) tests are in compliance with the pressure loss guarantee, it is likely that the pressure loss at 25 percent MCR would also be in compliance, provided gas flow was maintained at a reasonable level.

Subsection 3.2.3 addresses the 100 percent MCR pressure loss noncompliance in more detail.

2

3.3.1.7 Stoichiometric Ratio. The stoichiometric ratios determined during the Unit 1 load tests were all within the limit of 1.08 moles calcium per mole of sulfur removed. The stoichiometric ratios ranged from 1.01 to 1.05 moles calcium per mole of sulfur removed.

3.3.1.8 Limestone Consumption. The limestone consumptions, measured by the tank level method described in Section 3.1, for the Unit 2 load tests for the 100 and 50 percent load tests were under the limestone consumption guaranteed value. The 75 and 25 percent load tests were, however, above the guaranteed consumption rates. The measured limestone consumption rates are shown in Table 3-6.

Table 3-7 presents a comparison of the limestone consumption values measured using the differential tank level method with those calculated based on measured stoichiometric ratio and SO_2 removal rate. As observed with the Unit 1 tests, the limestone consumption rates based on stoichiometry differed significantly from those measured using the tank level method. Only the 25 percent MCR consumption rate based on stoichiometric ratio exceeds the guaranteed values. For the 75 percent MCR test, the limestone consumption measured by the different tank level method is 920 lb/h or 9 percent greater than the guarantee. The 75 percent MCR limestone consumption measured by the stoichiometric ratio method is 830 lb/h, or 8 percent, less than the guarantee. Within the accuracy of the measurements, it cannot be clearly determined whether the consumption is in compliance; therefore, the measured limestone consumption at 75 percent MCR would appear to be marginal.

The 25 percent MCR limestone consumption rates reflect operation of the wet scrubber at conditions which significantly exceed the design conditions. As discussed in Subsection 3.2.1.8, the limestone consumption rates for the 25 percent MCR tests are likely to not reflect the long-term performance of the system at these load conditions. Consequently, these values are inconclusive and are not an accurate indicator of system performance.

3.3.1.9 Water Consumption. The water consumption rates for the 100 percent and 75 percent load tests for Unit 2 were under these guaranteed values. The 50 percent and 25 percent load test water consumption values of 415 gpm and 243 gpm exceeded the guaranteed values of 382 gpm and 180 gpm, respectively. Actual values for water consumption are shown in Table 3-6. Noncompliance of the 50 and 25 percent MCR water consumption rates is discussed in Subsection 3.3.3.

3.3.1.10 Power Consumption. The power consumption by the wet scrubber is guaranteed for both 6,900 volt and 480 volt three-phase service. Power consumption for 6,900 volt service was under the guaranteed value for all unit loads. However, as observed with the Unit 1 tests, power consumption measurements for 480 volt service exceeded the guarantee for all load points. Table 3-6 presents the power consumption measurements for 6,900 volt and 480 volt service at each unit load. Power consumption data for Units 1 and 2 is contained in Appendix B.

For calculating the Unit 2 power consumptions, the following assumptions were made.

- Limestone slurry pump power was assumed to be equal to the power requirement specified in the Power Consumption User's List in the contract.
- All six reaction tank agitator motors were assumed to be operated continuously and were included in calculating the 480 volt power consumption.

As stated for the Unit 1 power consumption measurements, the noncompliance of the 480 volt power required appears to be primarily due to the assumption that all six reaction tank agitators are operated continuously. This is addressed in more detail in Subsection 3.3.3.

3.3.2 Rated Capacity Tests

As discussed in Subsection 3.2.2 for Unit 1, individual modules were monitored to comply with guarantees for sulfur dioxide emission rate and removal efficiency, particulate emission rate, and pressure loss. The six wet scrubber modules were tested in groups of three with the unit operating at approximately 75 percent MCR. Unit load and excess air were adjusted to establish a flue gas flow to the module which closely approximated the rated design flow of 2,613,000 lb/h. The results of these tests are summarized in Table 3-8.

3.3.2.1 SO_2 Emissions. The sulfur dioxide emissions for the Unit 2 rated capacity tests were all below the guaranteed value of 0.15 lb/MBtu. The average emission rates ranged between 0.0324 lb/MBtu (Modules A, C, and D) and 0.0497 lb/MBtu (Modules B, E, and F).

3.3.2.2 SO_2 Removal Efficiency. The measured sulfur dioxide removal efficiencies for the rated capacity tests were all above the 90 percent guaranteed level. The values for removal efficiency ranged between 93.01 percent (Module F) and 96.75 percent (Module D).

3.3.2.3 Particulate Emissions. The particulate emission rates observed during the rated capacity tests were all well within the guaranteed value of 0.020 lb/MBtu. The particulate emission rates ranged from 0.0019 lb/MBtu (Modules A, C, and D) to 0.0022 lb/MBtu (Modules B, E, and F).

3.3.2.4 Pressure Loss. All the pressure losses observed during the Unit 2 rated capacity testing were in excess of the guaranteed pressure loss of 2.54 inches of water. The pressure losses ranged from 4.14 inches of water (Module C) to 5.86 inches of water (Module B). All pressure losses listed in Table 3-8 have been corrected for flow rates that deviated from the rated design flow. Appendix A contains the measured pressure losses and summarizes the adjustment calculations.

3.3.3 Noncompliant Parameters

The parameters that did not meet the guaranteed values for Unit 2 were as follows.

- System pressure loss at 100 percent MCR.
- Limestone consumption for the 75 percent load tests.
- Water consumption at 50 and 25 percent load tests.

TABLE 3-8. SUMMARY OF GUARANTEED PARAMETERS VERSUS MEASURED VALUES--UNIT 2 RATED CAPACITY TESTS

	Guarantee	Module A	Module C	Module D	Module B	Module E	Module F
Total Flue Gas Flow Rate, adjusted pounds per hour	2,613,000	2,549,576	2,549,576	2,549,576	2,356,275	2,356,275	2,356,275
SO_2 Removal Efficiency, percent	90.00	95.69	96.31	96.75	94.33	93.59	93.01
SO_2 Emission Rate, pounds per million Btu	0.150	0.0324	0.0324	0.0324	0.0497	0.0497	0.0497
Particulate Emission Rate, pounds per million Btu	0.020	0.0019	0.0019	0.0019	0.0022	0.0022	0.0022
Pressure Loss, inches of water	2.54	4.50	4.14	4.51	5.86	4.89	4.83

- 480 volt power consumption at all loads.
- Module pressure loss for rated capacity tests.

Discussions addressing each of these parameters are included in the following subsections.

3.3.3.1 100 Percent MCR Pressure Loss. As discussed in Subsection 3.3.1.6, the wet scrubber pressure loss for the 100 percent MCR Unit 2 load test did not comply with the guarantee. The measured loss of 3.18 in. wc and gas flow of 8,912,000 lb/h was compared with the pressure loss correction curve (Figure 3-1). Based on the figure, the guaranteed loss at this flow appears to be slightly below 3 in. wc.

The 100 percent MCR flow for Unit 2 was significantly less than the flow measured for Unit 1 (8,912,000 lb/h versus 9,877,000 lb/h, respectively). Based on oxygen content measurements of the flue gas at the wet scrubber inlet, the difference appears to be due to significant differences in excess air operation of the steam generators. The average oxygen content for the Unit 1 tests was 6.7 percent in contrast with the 5.4 percent oxygen content observed during the Unit 2 tests. The observed difference in excess air levels would account for a majority of the difference between the Unit 1 and 2 flows. Consequently, the data for Unit 2 appears to be consistent and accurate. Therefore, the observed noncompliance of the 100 percent MCR pressure loss is considered to be an accurate assessment of system performance.

3.3.3.2 75 Percent MCR Limestone Consumption. The measured limestone consumption for the 75 percent MCR load test was 11,500 lb/h, 920 lb/h greater than the guarantee of 10,580 lb/h. This value was based on the differential tank level method of measurement. The limestone consumption estimated using the stoichiometric ratio method was 9,750 lb/h. Assuming that the accuracy of both methods is 10 percent, the measured limestone consumption rate cannot be conclusively stated to exceed the guarantee. Consequently, the Unit 2 wet scrubber system is marginal with respect to limestone consumption for the 75 percent MCR load test.

3.3.3.3 <u>50 and 25 Percent MCR Water Consumption</u>. The 50 percent MCR water consumption measurement was 415 gpm, 33 gpm greater than the guarantee of 382 gpm. The 25 percent MCR consumption was 243 gpm, exceeding the guarantee of 180 gpm by 63 gpm. The measured operating conditions indicate that the wet scrubber system was operated at gas flows which significantly exceeded the design conditions for both load tests. As discussed in Subsection 3.2.3.2, it is difficult to extrapolate the impacts of excessive gas flow on mist eliminator washing requirements; however, it is conceivable that increased gas flows may increase the consumption of water through more frequent washing of the mist eliminators. Although this would explain the higher water consumption rates at these loads, there is no basis for predicting the water consumption rate at design conditions given the data collected during either test. Consequently, the tests to verify compliance with the water consumption guarantee are inconclusive.

3.3.3.4 <u>480 Volt Power Consumption</u>. As stated in Subsection 3.3.1.10, the 480 volt power consumption measurements exceeded the guarantee values at all load points. The measured consumption was 330 kW, exceeding the 100 percent MCR guarantee by 18 kW and the 25 percent MCR guarantee by 110 kW. The same phenomenon was observed for the Unit 1 tests. As noted in Subsection 3.2.3.3 which discusses the Unit 1 results, there are several inconsistencies concerning the assumed number of operating reaction tank mixers in calculating the 480 volt consumption rates and in the overall determination of the guarantees based on the Power Consumption User's List in the contract. It should be noted that the 6,900 volt guarantees were satisfied at all unit load points, and that the total measured auxiliary power consumption did not exceed the total guaranteed power consumption for any test. Therefore, the deviation of the 480 volt power consumption from the guarantee does not appear to be significant with respect to the overall Unit 2 wet scrubber auxiliary power consumption.

3.3.3.5 <u>Rated Capacity Module Pressure Loss</u>. As described in Subsection 3.3.2, the individual module pressure losses at rated capacity significantly exceeded the guarantee. The measured pressure losses ranged from 4.14 in. wc for Module C to 5.86 in. wc for Module D. The guaranteed pressure loss is 2.54 in. wc. The same problem was noted for the Unit 1 wet scrubber. The gas flows during the rated capacity tests were close to the rated design flow of 2,613,000 lb/h and, therefore, required only slight adjustment of the measured pressure losses to design conditions. Consequently, the measurements appear to be accurate assessments of wet scrubber performance at rated capacity conditions.

4.0 CONCLUSION

4.1 UNIT 1 TESTS

The performance test results for the Unit 1 wet scrubber indicate that the overall performance of the system is satisfactory. As discussed in Subsection 3.2.3, the results indicate that the following guarantees were not met.

- SO_2 removal efficiency at 75 and 50 percent MCR.
- Water consumption at 25 percent MCR.
- 480 volt power consumption for all loads.
- Module pressure loss at rated capacity.

Insufficient SO_2 removal efficiency for the 75 and 50 percent MCR tests is attributed to incorrect information provided by the continuous monitoring system. Based on the data collected during these tests, the system appears to be easily capable of achieving this guarantee without violating any other guarantees. Water consumption measurements at 25 percent MCR were inconclusive since the operating conditions during these tests significantly exceeded the design conditions. The 480 volt power consumption measurements are considered to be insignificant since combined power consumption for both 6,900 volt and 480 volt service was well below the guaranteed total auxiliary power consumption by the wet scrubber.

The module pressure loss measurements at rated capacity clearly do not conform with the contract guarantees. It should be noted, however, that measurements of the Unit 1 wet scrubber system pressure loss were in compliance with the guarantee at all load points.

4.2 UNIT 2 TESTS

Results of the Unit 2 wet scrubber performance tests indicate that the system is in compliance with most of the guarantees. However, system pressure loss at 100 percent MCR and scrubber module pressure loss at rated capacity were not in compliance with the guarantees. Subsection 3.3.3 addresses the following results which were not within the guaranteed limits.

- Pressure loss at 100 percent MCR.
- Limestone consumption at 75 percent MCR.
- Water consumption at 50 and 25 percent MCR.
- 480 volt power consumption for all loads.
- Module pressure loss at rated capacity.

The pressure loss of the Unit 2 wet scrubber system at 100 percent MCR is not within the guarantee as determined using the pressure loss correction curve shown on Figure 3-1. Additionally, as noted for the Unit 1 tests, the pressure loss of individual modules was excessive. The flue gas flow used to evaluate the pressure loss on Figure 3-1 was determined by taking the average of the stoichiometric gas flow corrected for excess air and the measured flue gas flow. This method of calculating gas flow is consistent with the definition of gas flow stated in the wet scrubber contract. The gas flow determined for Unit 2 appears to be consistent with the other data, including the flows determined for the Unit 1 tests. Consequently, the results appear to be an accurate assessment of system performance at the tested conditions indicating nonconformance of the system with respect to the pressure loss guarantee at 100 percent MCR.

Limestone consumption at 75 percent MCR did not appear to meet guarantee; however, based on the estimated accuracy of the test data, the measured consumption rate cannot be conclusively stated to exceed the guarantee. Therefore, the Unit 2 wet scrubber performance was marginal with respect to limestone consumption for the 75 percent MCR load tests. Water consumption measurements at 50 and 25 percent MCR were inconclusive since the Unit 2 operating conditions during these tests exceeded the design conditions. As stated for the Unit 1 tests, the noncompliance of the 480 volt power consumption measurements is considered insignificant since the total power consumption for both 6,900 volt and 480 volt service were well within the total auxiliary power requirement guaranteed for the Unit 2 wet scrubber.

5.0 REFERENCE DOCUMENTS

1. Intermountain Power Project, Intermountain Generating Station Wet Scrubber and Sludge Conditioning Test Plan, File No. 9255.74.0203, Issue Date and Revision No. 060187-1.

2. Results of the June 1987 Scrubber System Performance Testing on Unit 1 at the Intermountain Generating Station in Delta, Utah by Interpoll.

3. Results of the July 1987 Scrubber System Performance Testing on Unit 2 at the Intermountain Generating Station in Delta, Utah by Interpoll.

4. EPRI FGD Chemistry and Analytical Methods Handbook, Chemical and Physical Test Methods, CS-3612, Volume 2, Project 1031-4 Final Report, July 1984.

5. EPA Code of Federal Regulations Part 40.

6. EPA Code of Federal Regulations Section 40, Part 60, Appendix A (Revised July 1, 1986).

APPENDIX A

CALCULATIONS FOR CORRECTED PRESSURE LOSSES

ADJUSTED PRESSURE LOSS CALCULATIONS
P1 = P2*(VD/(DD*60*VM))^2*DD/DM

UNIT 2 TEST 1

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
A	4.45	2,613,000	0.0465	2,504,954	0.0448	4.6651
C	4.10	2,613,000	0.0465	2,504,954	0.0448	4.2982
D	4.46	2,613,000	0.0465	2,504,954	0.0448	4.6756
B	4.81	2,613,000	0.0465	2,487,216	0.0459	5.2403
E	4.05	2,613,000	0.0465	2,487,216	0.0459	4.4123
F	4.00	2,613,000	0.0465	2,487,216	0.0459	4.3578

UNIT 2 TEST 2

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
A	4.45	2,613,000	0.0465	2,508,057	0.0446	4.6328
C	4.10	2,613,000	0.0465	2,508,057	0.0446	4.2684
D	4.46	2,613,000	0.0465	2,508,057	0.0446	4.6432
B	4.81	2,613,000	0.0465	2,369,192	0.0458	5.7628
E	4.05	2,613,000	0.0465	2,369,192	0.0458	4.8523
F	4.00	2,613,000	0.0465	2,369,192	0.0458	4.7924

UNIT 2 TEST 3

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
A	4.45	2,613,000	0.0465	2,635,718	0.0446	4.1949
C	4.10	2,613,000	0.0465	2,635,718	0.0446	3.8650
D	4.46	2,613,000	0.0465	2,635,718	0.0446	4.2043
B	4.81	2,613,000	0.0465	2,212,418	0.0455	6.5652
E	4.05	2,613,000	0.0465	2,212,418	0.0445	5.4064
F	4.00	2,613,000	0.0465	2,212,418	0.0445	5.3396

APPENDIX A
CALCULATIONS FOR CORRECTED PRESSURE LOSSES

ADJUSTED PRESSURE LOSS CALCULATIONS
P1 = P2*(VD*DM/(DD*DM))^2*DD/DM

UNIT 1 TEST 1

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
C	4.50	2,613,000	0.0465	2,664,534	0.0454	4.2252
E	4.85	2,613,000	0.0465	2,664,534	0.0454	4.5539
F	4.75	2,613,000	0.0465	2,664,534	0.0454	4.4600
B	5.10	2,613,000	0.0465	2,566,623	0.045	5.1155
D	5.10	2,613,000	0.0465	2,566,623	0.045	5.1155
E	4.55	2,613,000	0.0465	2,566,623	0.045	4.5638

UNIT 1 TEST 2

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
C	4.50	2,613,000	0.0465	2,689,166	0.0449	4.1025
E	4.85	2,613,000	0.0465	2,689,166	0.0449	4.4216
F	4.75	2,613,000	0.0465	2,689,166	0.0449	4.3304
B	5.10	2,613,000	0.0465	2,689,556	0.0411	4.2548
D	5.10	2,613,000	0.0465	2,689,556	0.0411	4.2548
E	4.55	2,613,000	0.0465	2,689,556	0.0411	3.7959

UNIT 1 TEST 3

Module	Measured Pressure Loss in. wc	Design Flow Rate lb/h	Design Density lb/cu ft	Measured Flow Rate lb/h	Measured Density lb/cu ft	Corrected Pressure in. wc
C	4.50	2,613,000	0.0465	2,532,740	0.0449	4.6249
E	4.85	2,613,000	0.0465	2,532,740	0.0449	4.9846
F	4.75	2,613,000	0.0465	2,532,740	0.0449	4.8819
B	5.10	2,613,000	0.0465	2,726,811	0.0446	4.4918
D	5.10	2,613,000	0.0465	2,726,811	0.0446	4.4918
E	4.55	2,613,000	0.0465	2,726,811	0.0446	4.0074

APPENDIX B

WATER AND POWER CONSUMPTION DATA

WATER CONSUMPTION DATA

Unit 1 FULL LOAD TESTING (6-3-87)

TIME	8:10	8:50	10:00	11:00	12:50	1:[illegible]0
change (hrs)	0	0.67	1.17	1.00	1.83	0.85
Mist Elimin Makeup Tank		23,550	47,020	33,500	79,120	28,91[illegible]
Seal Water		4340	8530	6240	13,100	5420
Recovered Water		11,620	22,660	16,920	37,420	16,[illegible]5[illegible]
Calc. Mist Elimin Wash (calc.)		19,210	38,490	20,400	66,020	23,50[illegible]
Mist Elimin. Wash						
Module "B"		5020	8880	6750	14,350	7020
Module "C"		4620	8770	6790	14,170	7090
Module "D"		5330	8570	4420	16,120	7130
Module "E"		3950	7280	5930	14,150	6050
TOTAL		18,920	33,500	23,890	58,790	27,[illegible]
Recovered Water						
Module "B"		2700	4450	3610	9830	6800
Module "C"		5320	5560	2700	7700	4[illegible]0
Module "D"		1780	5280	7610	13,710	76[illegible]0
Module "E"		4340	8550	5340	7530	6050
TOTAL		14,140	23,840	19,260	38,770	25,28[illegible]
Slurry Disch.						
Sump "A"		—	—	—	—	—
Sump "B"		—	15,480	9280	23,790	9910

IP12_006749

UNIT 1 <u>FULL LOAD TESTING (6-3-87)</u>

TIME	2:40	3:20	4:11	5:18	SUMMAR	
change (hrs)	0.98	0.67	0.85	1.12	9.14	gpm
					gals	
63 Mist Elimin Separator	36,490	24,860	61,170		334,620	610
Makeup Tank [illegible]						
65 Seal Water	5580	4270 *	4620	6150	58,250	106
			10,770			
64 Recovered Water	21,830	17,720	22,390	31,440	198,150	361
67 Mist Elimin Wash (Calc)	30,910	20,590	50,400		276,370	504
Mist Elimin Wash						
57 Module "B"	7410	4060	5340	5580	64,410	117
58 Module "C"	7400	5780	5290	8610	68,500	125
59 Module "D"	8920	3680	5230	4640	64,040	[illegible]
60 Module "E"	6300	3360	4130	4330	55,480	[illegible]
TOTAL	30,030	16,880	19,990	23,160	252,430	[illegible]
			43,150			
Recovered Water						
51 Module "B"	7230	3950	5600	7790	51,940	95
52 Module "C"	6560	4650	6800	8880	52,910	97
53 Module "D"	7710	3910	5840	8350	54,360	99
54 Module "E"	4330	4660	2550	9140	57,490	105
TOTAL	25,830	17,170	20,790	34,160	216,700	396
Slurry Disch				Time →	2.64 hrs	
Sump "A"	—	8050	10,210	13,510	31,770	201
				Time →	8.47 hrs	
Sump "B"	10,240	8420	10,170	13,870	101,160	199

* estimated from average flow rates

UNIT 1 75% LOAD TESTING (6-5-87)

TIME	12:55	2:05	2:49	3:48	4:1[illegible]
change (hrs)	0.92	1.17	0.73	0.98	[illegible]
Mist Elimin. Makeup Tank	29,338	33,652	22,550	26,526	27,46[illegible]
Seal Water	4492	5159	3416	4557	46[illegible]
Recovered Water	30,358	32,414	17,520	20,158	20,[illegible]
Mist Elimin. Wool (Calc.)	24,846	28,493	19,134	21,969	22,790
Mist Elimin Wool					
Module "B"	4196	10,036	4160	4210	4370
" "C"	6588	5489	5600	4360	4300
" "D"	5497	6708	3470	6680	4640
" "E"	4624	4913	2640	4390	2250
TOTAL	20,905	27,146	15,870	19,640	15,[illegible]
Recovered Water					
Module "B"	7750	9501	3880	4030	4100
" "C"	7382	9135	4320	6050	6240
" "D"	7710	9471	5220	7040	4780
" "E"	7591	9687	5310	6670	7950
TOTAL	30,433	37,794	18,730	23,790	23,670
Slurry Discharge Sump "B"	–	14,750	9890	11,640	14,080

IP12_006751

UNIT 1 75% LOAD TESTING (6-5-87)

TIME	5:21	6:20	7:17	SUMMARY	
change (hrs)	0.55	0.98	0.95	7.28 hrs	gpm
				gals	
Mist Elimin.	14,170	24,520	30,260	208,490	477
Makeup Tank					
Seal Water	2570	4410	4590	33,870	78
Recovered Water	11,980	20,970	25,470	178,900	426
Mist Elimin. Wash (calc.)	11,600	20,110	25,670	174,620	399
Mist. Elimin Wash					
Module "B"	2570	4200	4520	39,242	90
Module "C"	2370	5160	6000	39,867	91
Module "D"	2810	4410	4450	38,665	89
Module "E"	2250	3980	6460	31,507	72
TOTAL	11,000	17,750	21,430	149,300	342
Recovered Water					
Module "B"	2280	6690	7980	46,210	106
Module "C"	3470	6010	5940	48,550	111
Module "D"	2670	4800	4460	46,150	106
Module "E"	4550	7940	7830	57,508	132
TOTAL	12,970	25,440	26,210	198,418	455
Slurry Disch.			Time →	6.36 hrs	
Sump "B"	5210	11,300	11,160	77,330	203

IP12_006752

UNIT 1   50 % LOAD TESTING (6-6-81)

TIME	12:52	1:57	3:08	3:28	4:28	5:27
change (hr)		0.92	1.18	0.33	1.00	0.98
Mist Elimin Makeup Tank		22,590	27,950	6550	18,710	19,740
Seal Water		4070	4420	1340	3700	3760
Recovered Water		20,930	23,640	8200	19,590	17,66[illegible]
Mist. Elimin Wash (Calc)		18,520	23,530	5210	15,010	15,980
Mist Elimin Wash						
Module "B"		4360	7100	1390	3700	3790
Module "D"		7080	4130	1290	3810	5560
Module "E"		3620	6930	930	3180	3720
TOTAL		15,060	18,160	3610	10,690	13,070
Recovered Water						
Module "B"		8020	8500	2710	7970	8100
Module "D"		8310	7400	2250	6400	6390
Module "E"		8830	9610	2980	7310	5440
TOTAL		25,160	25,510	7940	21,680	19,930
Slurry Disch Sump "B"		10,360	14,140	4390	18,390	11,420

Lab Analysis

	Density	pH	pH Meter
Module "B"	11.0	6.02	6.12
" "D"	12.0	6.05	6.12
" "E"	9.8	6.18	6.23

IP12_006753

UNIT 1 50% LOAD TESTING (6-6-?)

TIME	6:11	7:00	8:02	SUMMARY	
change (hrs)	0.73	0.87	1.03	6.99 hrs	
				gals	gpm
Mist Elimin Makeup Tank	16,290	16,060	23,480	151,370	361
Seal Water	2920	3040	3990	27,240	65
Recovered Water	14,240	12,830	18,050	135,140	322
Mist Elimin. Wash (Calc)	13,370	13,020	19,490	124,130	296
Mist Elimin Wash					
Module "B"	2800	3040	7310	33,490	80
Module "D"	3310	3030	7060	35,270	84
Module "E"	4060	3670	3360	29,470	70
TOTAL	10,170	9740	17,730	98,230	235
Recovered Water					
Module "B"	6010	5490	7450	54,250	129
Module "D"	4750	4230	7000	46,730	111
Module "E"	4870	5950	7250	52,240	125
TOTAL	15,630	15,670	21,700	153,220	365
Slurry Disch Sump "B"	9190	9750	12,680	90,320	215

IP12_006754

UNIT 1 — 25 % LOAD TESTING (6/7/87)

TIME 11:50	12:40	1:45	2:24	3:22	4:30
change (hrs)	0.83	1.08	0.65	0.97	1.13
Mist Elimin Makeup Tank	13,830	15,200	13,110	16,430	19,150
Seal Water	3880	4340	2990	4000	4780
Recovered Water	10,220	15,970	10,360	13,010	11,510
Mist Elimin Wash (Calc.)	9950	10,860	10,120	12,430	14,370
Mist Elimin Wash					
Module "B"	3340	3310	5300	3820	6770
Module "E"	2990*	3310	2360	4790	4280
TOTAL	—	6620	7660	8610	11,050
Removed Water					
Module "B"	5870	7060	4900	5120	5960
Module "E"	6810	8640	5980	8380	10,320
TOTAL	12,680	15,700	10,880	13,500	16,280
Slurry Disch Sump "B"	6170	11,980	7795	1910	11,570

* estimated from average flow rate

IP12_006755

UNIT 1   25 % LOAD TESTING 6/7/87

TIME	5:03	5:58	6:58	SUMMARY	
change (hr)	0.55	0.92	1.00	7.13 hrs	
				gal	gpm
Mist Elimin. Makeup Tank	9630	11,660	14,750	113,760	266
Seal Water	2440	3760	4320	30,510	71
Recovered Water	4980	6690	11,660	84,400	197
Mist Elimin Wash (Calc)	7190	7900	10,430	83,250	195
Mist Elimin Wash					
Module "B"	1950	3380	3440	31,310	73
Module "E"	2330	2320	3270	25,650	60
TOTAL	4280	5700	6710	56,960	133
Recovered Water					
Module "B"	2520	3900	6000	41,330	97
Module "E"	3720	5510	7960	57,320	134
TOTAL	6240	9410	13,960	98,650	231
Slurry Disch					
Sump "B"	6340	9980	11,610	67,655	158

IP12_006756

UNIT 1 MODULE CAPACITY TESTING (6-?-87)

TIME	8:05	9:06	10:06	12:04	1:32	3:04
change (hr)		1.02	1.00	1.97	1.47	1.53
Mist Elimin Makeup Tank		22,730	27,970	27,640	45,730	40,170
Seal Water		6120	5690	5840	8440	8970
Recovered Water		29,340	17,590	16,710	18,990	23,190
Mist. Elimin. Wash (Calc)		16,610	22,280	21,800	36,790	31,200
Mist. Elimin Wash						
Module "C"		6050	5960	8390	11,310	9740
Module "E"		5100	4860	5630	10,790	8250
Module "F"		6320*	6800	6190	12,060	10,110
TOTAL		—	17,620	20,210	34,160	28,100
Recovered Water						
Module "C"		9180	5260	5640	7950	10,230
Module "E"		9170	7680	8270	10,440	10,710
Module "F"		4970*	4980	4400	5010	7670
TOTAL		—	17,920	18,310	23,400	28,610
Slurry Disch.						
Sump "B"		14,740	14,900	17,170	15,610	31,380

* estimated from average flow rates

UNIT 1 MODULE RATED CAPACITY TESTING (6-9-87)

TIME	4:05	5:04	SUMMARY	
change (hrs)	1.02	0.98	8.99 hrs	
			gals	gpm
Mist Elimin. Makeup Tank	28,590	28,010	220,840	409
Seal Water	5220*	5690	45,970	85
Recovered Water	23,260	28,370	157,450	292
Mist Elimin. Wash (Calc)	—	22,320	174,870	324
Mist Elimin. Wash				
Module "C"	6520	6470	57,440	106
Module "E"	7670	5750	48,050	89
Module "F"	6060	8150	55,690	103
TOTAL	20,250	20,370	161,180	298
Recovered Water				
Module "C"	8550	8010	54,820	102
Module "E"	8340	8010	62,620	116
Module "F"	8410	7980	43,370	80
TOTAL	25,300	24,000	160,810	298
Slurry Disch.				
Sump "B"	14,110	11,640	119,550	222

*estimated from average flow rates

IP12_006758

/8/87 UNIT 2	TEST 1	TEST 2	TEST 3	END
TIME	9:01 AM	11:50AM	1442	1700
S. SLURR TANK	66½"	89"	117"	137'
MAKEUP 2905	88117145	88229498	88349971	88436 59
SEAL WATER 2902	9368598	9368598	9368598	9368598
REC. WATER 2906	46690385	46694246	46704684	46710623
MB GAS R.H. METER 30039 95X4000	3225	3230	3200	3248
ACTUAL	3150	3155	3125.8	3173
E FLOW 40106-08				
Module A	1930 2108 2002	193254569210	193542861220	193732512915
C	165780392715	166032701660	166300883882	166484955194
D	109 2139 5002	110 2142 7863	214470526227	214667474859
F	881 54207372	88392989657	8865819 7147	888 6120 6132
REC. WTR FL 40116-118				
Module A	454 7195 1229	4555684 1905	045726096343	4585052 9917
C	585 86025252	58735428291	58845099808	589 40008885
D	488 10040596	488 4111 5229	48907030337	490 36755311
F	99 6886 1855	100 5960 5332	10186930211	10287634356
SLURRY FEED 2X08				
Module A	132860	1330869	1333448	1335128
C	1129688	1131887	1134399	1136159
D	764485	766478	768301	769359
F	476380	477987	479812	481209
REC. WATER TO SUMP	0	9312	19503	25507
SUMP FLOW TOT.	0	6876	14180	19768

IP12_006759

UNIT 2

11:40

JULY 9-10, 1987 WET SCRUBBER, UNIT 2, 75 % LOAD

TIME		2337	0200	0400	0715
L.S. Tank LVL.		53"	69½"	97"	119½"
M.E MAKEUP 2905		89619211	89704011	89813620	89897870
SEAL WTR 2902		9368598	9368598	9368598	9368598
REC WTR 2906		46869737	46882873	46899310	46912532
COMB GAS RH WATR FLOW 30039	READING	3310	3300	3310	3300
	ACTUAL	3232	3222.7	3232	3222.7

Readinding/4096 ×4000 = ACTUAL

ME FLOW					
	MOD A	1966653130 58	1968 75102204	1971 62454296	197392680066
	MOD B	1694 6581 9547	169667796309	169955842505	17016660 0456
V106	MOD D	2174 9526 4026	2176 9359 2520	2179 7876 7494	2181 8614 3489
	MOD F	917 1257 4477	919 3310 8363	922 0906 1401	924 2116 7448
REC. WTR, FLOW					
	MOD A	46542023449	46553323182	46565781455	46575446978
40116	MOD C	593 9287 4478	59399627906	594 88053814	594 9661 6416
	MOD D	4 96 99843634	49705635098	49712544715	4971807 2905
	MOD F	108 4414 8099	108 44492456	108 44694989	108 4481 9667
SLURRY FEED					
	MOD A	1358149	1359380	1362087	1364071
2X08	MOD C	1159105	1160252	1162829	1164573
	MOD D	785922	786895	789505	791216
	MOD F	501062	501628	503096	505037
WATER to SUMP FS= 10 FPS		0	7498	16942	23606
SUMP FLOW TOT. FS = 10 FPS		0	6377	13693	19311

IP12_006760

UNIT 2

WET SCRUBBER, UNIT 2, 50% MCR 7/11/87

		0225	0504	0717
TIME	0010	0225	0504	0717
L.S. Tank LVL.	67"			
ME. MAKEUP 2905	90483485	90536527	90606024	90660674
SEAL WTR 2902	9368598	9368598	9368598	9368598
REC. WTR 2906	47002779	47015630	47030815	47043659
COMB GAS RH WTR. FLOW 30039 READING	3320	3310	3325	3320
ACTUAL	3242	3232.4	3247.1	3242
ME FLOW				
40106 MOD A	1989 5566 6652	1991 6594 7483	1994 3402 8965	1996 5212 909
MOD C	1716 5732 2571	1718 3036 7753	1720 7209 8621	1722 3620 063
MOD F	939 1980 2524	941 0153 1378	943 2324 3770	944 8539 031
REC. WTR FLW				
40116 MOD A	469 1122 5543	469 1793 0477	469 2557 9272	469 3162 [illegible]
MOD C	597 7979 2515	597 8756 3129	597 9713 5889	598 0527 [illegible]
MOD F	110 1614 6819	110 1619 1311	110 1629 0911	110 1634 1541
SLURRY FEED				
2X08 MOD A	1375074	1376196	1378053	1379739
MOD C	1175723	1176758	1178749	118009[illegible]
MOD F	512785	513513	514849	515894
REC. WTR TO SUMP TOT. FS=10	0	6900	15920	22751
SUMP FLOW TOTALIZER FS=10	0	5771	12573	18120

$CF = FS \times 0.0245 \times (ID)^2$

IP12_006761

UNIT 2 WET SCRUBBER, UNIT 2, 25% MCR JULY 11-12, 1987

TIME	0010	0229	0454	0715
ME MAKEUP 2905	91119182	91154648	91196617	912226[illegible]
SEAL WATER 2902	9368598	9368598	9368598	9368598
REC. WTR. 2906	47125103	47125103	47125103	47125103
COMB GAS R.H. WTR. FLOW 30039 RDG.	3200	3220	3210	3220
ACTUAL	~~3[illegible]~~			
ME. FLOW MOD C	17345474 3468	173549088155	17367~~8~~8~~7~~44604	1738113524 88
0106 MOD F	95688029013	9580610 6391	0959 33564474	96024725 3[illegible]
REC. WTR. FLW MOD C	6005711 8531	6013448 0980	6023976 6510	6025769 7[illegible]
0116 MOD F	11203040369	0112 6892 8056	1136070 6782	1136961 14[illegible]
SLURRY FEED MOD C	1187493	1188809	1190362	1192685
x08 MOD F	522083	523110	524289	526115
REC WTR TO SUMP TOT.	0	3093	6325	17540
FLOW TOTALIZER	0	5949	12252	18336

lost signal for partial time

IP12_006762

UNIT 2 WET SCRUBBER RATED PERF. TEST. MODULES

July 16, 1987

TIME	0729	1058	1245	1530
L. Tank LVL. 2911	33.0	31.6	29.7	27.7
HE. MAKEUP 2905	94338412	94414210	94507853	94581635
SEAL WATER 2902	9368598	9368598	9368598	9368598
REC. WATER 2906	47329504	47329504	47331875	47331875
AMB GAS RHT RDG. TR. FLOW 30039 ACT.	3140	3120	3160	3140
HE. FLOW 2106 MOD A	20425348 7404	20449266 5180	20475793 6003	20499443 978
MOD C	17988767 0006	18010870 7586	18038717 8474	18061920 39
MOD D	22305493 0385	22328060 3994	22352845 4117	22375337 23
REC. WTR FLOW 2116 MOD A	489 7720 3166	490 2469 6597	490 8322 9412	492 4095 9
MOD C	6254 7267 7720	6268 0036 742	627 4960 7609	628 3929 111
MOD D	519 8153 1692	521 1992 1246	522 2987 5429	523 5228 7640
SLURRY FEED 2108 MOD A	1418744	1421223	1423925	1426502
MOD C	1250239	1252484	1255762	1258222
MOD D	817043	818213	819703	821020
REC. WTR TO SUMP. TOT.	0	5420	11559	15978
SUMP FLOW TOT.	0			

changed to correct pump ≈ 8:15 AM

Sump pump was changed over again (after flow meter was moved to other pump) use data from previous rated capacity test for sump pump flow rate.

IP12_006763

UNIT 2

WET SCRUBBER UNIT 2, Rated Capacity Test —

Rated Capacity Test, UNIT 2, MODULES B, E, F. July 14, 1987

TIME 2911		0840	1128	1428	1820
TANK LVL.		27.1	24.7	22.9	20.8
M.E. MAKEUP 2905		92848277	92938759	93022236	93144799
SEAL WATER 2902		9368598	9368598	9368598	9368598
REC WTR 2906		47204907	47204907	47204907	47210146
COMB GAS RHT. WTR. FLOW 30039	READING ACTUAL	3190	3160	3150	3190
M.E. FLOW					
40106	MOD B	18457917 2000	18485358 1650	18513822 1017	18550638 3858
	MOD E	7064059 1260	7093279 6548	7121924 4194	7161006 7208
	MOD F	10042442 0491	10069633 2369	10097304 7552	10131856 1506
REC. WTR. FLOW					
40116	MOD B	4946795 6263	4958170 1601	4970972 1883	4986671 836
	MOD E	1838142 9893	1849263 1171	1852695 4605	1868794 7295
	MOD F	1294757 6823	1306995 4819	1320070 0454	1335703 8585
SLURRY FEED					
2208	MOD B	980823	984269	987110	989787
2508	MOD E	312598	315883	318413	320878
2608	MOD F	557191	558971	560791	563372
REC. WTR. TO SUMP (TOT.) FS=20		0	10356	~~[illegible]~~ 23486	38881
SUMP FLOW (TOT) FS=10		0	6850	15,115	24967

Low speed 4.3 - 4.4 fps high speed - 6.9 fps

POWER CONSUMPTION DATA

UNIT #1 PERFORMANCE TESTING POWER CONSUMPTION

Description	Avg. KV	KVA	KW	PF	V	A
Scrubber HP Spray Pump 1A	6.948	269.5	244.0	.91	6.950	22.80
Scrubber LP Spray Pump 3A	6.958	276.9	252.8	.91		
Scrubber HP Spray Pump 1B	6.775	261.0	244.0	.93	6.778	23.05
Scrubber IP Spray Pump 2B	6.956	275.5	251.6	.91	6.956	23.24
Scrubber LP Spray Pump 3B	6.955	244.4	222.1	.91	6.954	20.77
Scrubber HP Spray Pump 1C	6.761	272.1	253.7	.93	6.759	24.46
Scrubber IP Spray Pump 2C	6.758	248.5	231.4	.93	6.764	22.46
Scrubber LP Spray Pump 3C	6.783	243.6	226.3	.93	6.778	21.67
Scrubber HP Spray Pump 1D	6.780	259.2	243.2	.94	6.783	22.82
Scrubber IP Spray Pump 2D	6.781	256.0	239.3	.93	6.776	22.26
Scrubber LP Spray Pump 3D	6.778	241.6	223.9	.93	6.776	21.46
Scrubber HP Spray Pump 1E	6.760	235.5	217.1	.92	6.762	21.39
Scrubber IP Spray Pump 2E	6.762	249.1	232.3	.93	6.762	22.35
Scrubber LP Spray Pump 3E	6.778	240.1	224.4	.93	6.779	21.25
Scrubber HP Spray Pump 1F	6.954	275.5	251.7	.91	6.953	23.31
Scrubber IP Spray Pump 2F	6.957	257.1	236.7	.92	6.952	21.61
Scrubber LP Spray Pump 3F	6.948	247.1	225.5	.91	6.947	20.85
Mist Eliminator Wash Pump 4A	472.7	59.65	41.92	.70	471.3	69.02
Mist Eliminator Wash Pump 4B	473.0	39.56	17.52	.44	472.5	47.03
Reaction Tank Mixer 1A	473.8	51.06	41.48	.81	473.9	57.57
Reaction Tank Mixer 1B	473.9	49.33	39.46	.80	474.2	59.45
Reaction Tank Mixer 1C	473.9	51.23	41.72	.81	474.1	63.88
Reaction Tank Mixer 1D	472.0	42.89	33.94	.79	471.2	50.16
Reaction Tank Mixer 1E	471.5	43.30	34.35	.79	471.1	50.88
Reaction Tank Mixer 1F	471.3	44.88	35.49	.79	470.2	54.61

UNIT #2 PERFORMANCE TESTING POWER CONSUMPTION

Description	Avg. KV	KVA	KW	PF	V	A
Scrubber HP Spray Pump 1A	6.874	279.6	256.2	.92		
Scrubber IP Spray Pump 2A	6.877	271.9	247.2	.91		
Scrubber LP Spray Pump 3A	6.879	251.6	227.8	.91		
Scrubber HP Spray Pump 1B	6.884	275.4	250.8	.91		
Scrubber IP Spray Pump 2B	6.888	266.7	245.2	.92		
Scrubber LP Spray Pump 3B	6.881	251.9	228.5	.91		
Scrubber HP Spray Pump 1C	6.887	279.3	257.8	.92		
Scrubber IP Spray Pump 2C	6.889	267.2	245.2	.92		
Scrubber LP Spray Pump 3C	6.904	257.7	236.1	.92		
Scrubber HP Spray Pump 1D	6.901	280.2	255.7	.91		
Scrubber IP Spray Pump 2D	6.904	268.7	243.3	.91		
Scrubber LP Spray Pump 3D	6.903	246.8	224.0	.91		
Scrubber HP Spray Pump 1E	6.903	276.1	255.8	.93		
Scrubber IP Spray Pump 2E	6.902	269.8	245.6	.91		
Scrubber LP Spray Pump 3E	6.907	254.3	233.1	.92		
Scrubber HP Spray Pump 1F	6.896	278.0	256.5	.92		
Scrubber IP Spray Pump 2F	6.890	261.7	239.0	.91		
Scrubber LP Spray Pump 3F	6.883	251.8	228.1	.91		
Limestone Slurry Tank 2B	464.3	50.36	41.44	.82	463.5	60.75
Mist Eliminator Wash Pump 4B	458.6	67.12	52.36	.78	—	—
Reaction Tank Mixer 1A	459.2	42.76	33.91	.79		
Reaction Tank Mixer 1B	459.3	44.39	35.92	.81	458.6	53.25
Reaction Tank Mixer 1C	459.2	41.38	32.95	.80		
Reaction Tank Mixer 1D	458.8	42.49	34.07	.80		
Reaction Tank Mixer 1E	458.9	39.95	31.41	.79		
Reaction Tank Mixer 1F	459.5	39.65	31.25	.79		
Limestone Pulverizer Low Pressure Lube Oil Pump 1A6A	455.6	950.4	493.0	.52	455.1	1.204
Limestone Pulverizer Low Pressure Lube Oil Pump 1A6B	454.7	1.090	459.7	.42	454.1	1.387
Limestone Pulverizer Low Pressure Lube Oil Pump 1B6A	454.4	923.5	419.6	.45	455.2	1.189
Limestone Pulverizer Low Pressure Lube Oil Pump 1B6B	455.5	936.9	496.3	.53	454.9	1.190
Limestone Pulverizer Low Pressure Lube Oil Pump 1C6A	460.3	952.3	421.2	.44	459.5	1.183
Limestone Pulverizer Low Pressure Lube Oil Pump 1C6B	455.0	966.0	427.2	.44	454.3	1.216